The AUTOMATIC ELECTRIC Technical Journal

magazine devoted to progress in communication engineering

UNIVERSITY OF MICHIGAN
JUN 5 1953
ENGINEERING LIBRARY

In this issue:

SIDELIGHTS ON THE DEVELOPMENT OF THE STROWGER AUTOMATIC DIRECTOR . . . . *H. P. Mahoney*

AUTOMATIC CALL RECORDING AND ACCOUNTING IN THE SATT SYSTEM . . . . *J. E. Ostline*

THE PREPAY PAYSTATION REPEATER . . . *Karl F. Steinhauer*

THE AUTOMATIC PRIVATE TELEPHONE SYSTEM OF THE BELGIAN NATIONAL RAILWAYS . . . . *R. F. Stehlik*

STROWGER AUTOMATIC SWITCHING FROM REVERTIVE PULSE SOURCES . . . . *W. J. Phillips*

May, 1953

Issued by

AUTOMATIC ELECTRIC COMPANY
Chicago, U. S. A.
and affiliated companies

Contributors to this issue

HARRY P. MAHONEY, since 1936 has been chief engineer of Associated Telephone and Telegraph Company, and consulting engineer for Automatic Electric Company and other affiliates of the Automatic group. His service dates from 1905 and has covered a wide range of activities, including engineering, installation, operating, development and sales. He has served as officer and director of many of the companies in the Automatic Electric group, and has travelled widely in all parts of the world in the interest of the Company's customers and affiliates. In his article on the Director he speaks with first-hand authority, since he was associated with its early application to the London and Havana networks.

JOHN E. OSTLINE, a native of Sweden, came to the United States in 1905, and soon thereafter became engaged in the construction, maintenance, and operation of various telephone properties. Later he took up traffic engineering, specializing in call indicator, AB toll, and other facilities relating to multi-office networks. He joined Automatic Electric Company in 1921, and then spent several years in England assisting in the conversion of the London telephone system to automatic operation using the Strowger "Director." Since his return to Chicago he has made many other important contributions to automatic switching in metropolitan areas, a notable example being the development of automatic toll ticketing. He is a Fellow of the American Institute of Electrical Engineers.

KARL F. STEINHAUER received the degree of Bachelor of Science in Electrical Engineering in 1932 from Washington University, Saint Louis, Missouri. His early experience in the communications field dates from 1936 and included work with Southern Bell and three years in the U.S. Army Signal Corps in which he became a Captain. He entered the employ of Automatic Electric Company in 1947, and for some time was in charge of circuit explanation writing and also acted as instructor in circuit operation for the Automatic Electric Training School, after which he was transferred to the Circuit Adaptation group. For the past year he has been assigned to Technical Publications.

R. F. STEHLIK is Chief Engineer of Automatique Electrique, S. A. (ATEA), Antwerp, the Belgian affiliate of Automatic Electric Company. He entered the laboratories of Automatic Electric Company, Chicago, in 1919, and was appointed Chief Development Engineer of Automatique Electrique, S. A. in 1927. Mr. Stehlik's name is closely identified with many of the fundamental developments in automatic switching. A large number of patents have been filed in his name, and notable amongst his original contributions was the pioneer development, carried out in collaboration with Mr. J. E. Ostline, on automatic toll ticketing.

WILLIAM J. PHILLIPS received his formal training at the universities of Minnesota and Alberta, joining Automatic Electric Company in 1937. After attending the training school, he spent two years in installation work in the United States, and early in 1941 went to Hawaii to supervise Strowger Automatic installations for the United States Navy. He served there until 1946 and received the Navy's Meritorious Civilian Award. Later he supervised installations at Montevideo, Uruguay, and at Park Ridge, Ill., and then worked in the Laboratories on Director and toll ticketing systems. He is now staff sales engineer for Automatic Electric Sales Corporation.

Copyright 1953
By Automatic Electric Company

The AUTOMATIC ELECTRIC TECHNICAL JOURNAL

A Magazine Devoted to Progress in Communication Engineering

Issued By

AUTOMATIC ELECTRIC COMPANY

and affiliated companies

Address all communications to: 1033 W. Van Buren Street, Chicago 7, U.S.A.

EDITORIAL ADVISORY BOARD

K. W. GRAYBILL — C. F. FFOLLIOTT — A. E. WOODRUFF — L. L. RUGGLES — C. J. DIEHL — F. L. KAHN

R. STEHLIK, Antwerp, Belgium — D. GALASSI, Milan, Italy — W. W. ASHWORTH, Brockville, Canada — C. R. HUGHES, Toronto, Canada

L. DEROISY, Antwerp, Belgium — C. MIGLIASSO, Milan, Italy

H. E. CLAPHAM, *Editor*

May, 1953 — Price: 50 cents per copy — Vol. 3, No. 3

SIDELIGHTS ON THE DEVELOPMENT ON THE STROWGER AUTOMATIC DIRECTOR

By H. P. MAHONEY

SYNOPSIS: ***Nationwide automatic networks—storage and translating facilities—origin of Director—application to London and Havana networks—the Director and tandem trunking—the Director in toll ticketing networks—technical aspects.***

THE rapid progress that is being made in nationwide operator toll dialing and automatic toll ticketing in telephone networks has focused attention on the need for broad planning so that developments in trunking arrangements and in area and station numbering may proceed on an orderly basis. These developments are reflected in the growing adoption of the 2-5 numbering plan (two letters and five digits) in both Independent and Bell exchanges, so that calls may be dialed into such exchanges in accordance with the nationwide numbering pattern.

In connection with these developments, much has been said in recent telephone literature about the inherent flexibility of automatic switching systems which regularly provide registration, translation, and sending facilities, sometimes referred to as "common control" systems. Often implicit in such literature is the assumption that a switching system either must be inherently of the common control type, or alternatively it must be inherently incapable of being equipped to provide common control features. Such an assumption ignores the fact that the Strowger system has no such limitations, since with the addition of the Director it may be endowed with all needed common control facilities, or a system may be installed initially without the Director thus avoiding commitments to common control facilities in advance of the time when such facilities are needed.

As further progress is made in toll switching techniques, including the expansion of subscriber toll dialing over broad areas, the added flexibility provided by the Director will undoubtedly grow in importance. The predominantly large number of Strowger (step-by-step) exchanges now in service in both Bell and Independent areas suggests the need for a broad understanding of the functions of the Director in Strowger networks and of its origin and historical background. That is the purpose of this article.

For some years there were two schools of thought as to the preferred method of trunking between the offices of an automatic multi-office telephone network. Some advocated the development of multi-office exchange trunking along the lines of the conventional straightforward Strowger system, with its direct dial control of switches and its direct groups of trunks from each office to all others in the network. Others advocated the use of machine-driven equipment which included facilities for electro-mechanically storing all digits of the number dialed by the calling subscriber and sending them at a predetermined time to establish the connection.

These storage and sending facilities were also capable of translating certain digits of the number —usually the first two or three, known as the code —to other digits which might differ in number or numerical value from those which the subscriber originally dialed. This translation was usually arranged, if used in a multi-office area, to prefix one or more digits to the number, either for the purpose of routing the call to its destination over an alternate trunk route, or to take advantage of the economies of tandem trunking, without in either case departing from the universal numbering plan adopted for the area.

For the purpose of this discussion, we may define "tandem trunking" as an arrangement wherein two or more offices are so located geographically that they are reached, in tandem, over the same group of trunks, rather than over direct trunks to each office. By "universal numbering" is meant a numbering plan in which the number to be dialed to reach any given station is the same regardless of the point of origin of the call in the area covered by that numbering plan. The numbers are usually comprised of the same number of code letters and digits. One purpose of the digit storage, translation, and sending facilities described in the foregoing is to achieve compatability between tandem trunking and universal numbering.

The so-called machine-driven systems differ in many fundamental ways from the Strowger system. They employ switching mechanisms operated from continuously rotating shafting driven by common motors, the motion of the individual switches being controlled by clutches. Digit storage and sending are inherent in such systems because they are incapable of direct dial control. In the Strowger system, on the other hand, each switch has its own electro-magnetic drive, and may therefore be operated directly from the subscriber's dial or from any other external pulse source.

The Strowger system never did, nor does it today, require or depend upon the storage and translation of a subscriber's call as was the case with the machine-driven systems. The Strowger system has always been primarily a straightforward dial controlled system which makes for speed and simplicity. Strowger engineers were aware of the storage and translation features but saw no need to incorporate them into the system until the industry had developed to the point where exchange networks were of sufficient size to introduce intricate trunking problems.

When digit storage, translation and sending facilities are required in a Strowger network—for example, to meet the requirements of tandem trunking and universal numbering—they are supplied by the Director,[1] which is so named because it is made easily accessible to the calling line for the purpose of "directing" the originating calls to their proper destinations. In performing this function, the Director receives all the digits of the number dialed by a subscriber and places them in storage for a few seconds on relay groups provided for that purpose. This storage feature is necessary so that the code may be known to the Director to enable it to make the required translation for routing the call to its destination.

1. THE DIRECTOR FOR AUTOMATIC TELEPHONE SWITCHING SYSTEMS. Arthur Bessey Smith. *A.I.E.E. Transactions*, Vol. 67, Part 1, 1948. Reprinted in *The Automatic Electric Technical Journal*, July, 1948.

It should be explained at this point that a translation of the code is not always required. Whether a code is translated into other digits or into more or fewer digits depends on the inter-office trunking arrangements. Where no translation is needed, the Director sends out the code portion of the number in its original form.

As soon as the code portion of the number is known, and regardless of whether the code is composed of letters or digits or a combination of the two, the Director starts sending out the number, either as received or in translated form. This feature results in the completion of the connection within two or three seconds following the dialing of the final digit of the number by the subscriber. This almost imperceptible delay, for translating and sending, results from the fundamental straightforward trunking characteristics of the Strowger system. The total holding time for the Director on each call averages only 16 to 20 seconds in a system employing seven-digit subscriber numbers.

A code translation may be so arranged in the Director that a call to the destination corresponding to the code dialed is first directed over a preferential trunk route. When the call has progressed to a point where the Director has sent two, or possibly more, digits of the code, depending on the trunking arrangement, and finds that no trunks are available via that route at the moment, the Director senses that condition and immediately releases that portion of the connection already set up. Then, by means of a different translation of the code, it sends the call to its destination via an alternate trunk route. The functions involved in this process, including digit storage, translation, and sending over preferential or alternate routes, are all functions of the Director.

As far back as the period of the first world war, the telephone administrations of a number of large cities had started to convert their systems from manual to automatic service. Most of these conversions were made with conventional Strowger equipment serving a rather large number of subscribers. In the United States, cities whose exchanges were being enlarged and converted to automatic included Los Angeles, Calif., Grand Rapids, Mich., Columbus, Ohio, Minneapolis, Minn., and others. Abroad, cities whose exchanges were undergoing conversion included Buenos Aires, Berlin, Havana, Manila, Sydney, Melbourne and Winnipeg.

Among the telephone administrations abroad which were keenly interested in the problem of multi-office trunking were those of the British, German, and Australian Post Offices. The Germans preferred to develop their manual-to-automatic conversion techniques by use of the conventional Strowger system with direct trunks to and from all offices. This was the basis for developing the two large networks of Berlin and Munich. On the other hand, the British Post Office, in considering the transition of the London network from manual to automatic working, found it desirable to give thought to the adoption of a system with digit storing and translation features in order to make use of tandem trunking. It was believed that some system embodying these features would ultimately be required in the city of London due to the complexity of the exchange network, the need for making most effective use of existing trunk routes, and the desirability of avoiding direct trunks between all offices.

The problems of adopting an effective system for the conversion of the London network from manual to automatic operation and of providing for the future expansion of the London exchange to serve an undetermined number of central offices and an equally undetermined number of subscribers were given long and serious consideration by British communications engineers. During this time various phases of these problems provided subject matter for numerous technical papers, particular attention being given to the methods of trunking between offices of metropolitan automatic networks. These technical papers, prepared by engineers of the British Post Office and those of the telephone equipment manufacturing companies, were usually presented under the auspices of the Institution of Electrical Engineers. One such paper, sponsored jointly by one of the manufacturers and the British Post Office, treated in great thoroughness with the transition of the London network from manual to automatic on the basis of the conventional Strowger system.

It was not until after the close of the first world war that the British Post Office came to a decision

that a system having facilities for registration and translation should be provided for the London network. This decision having been made, an order was placed for a trial installation of a small number of lines of a machine-driven register-translating system, although the British Post Office had previously adopted the Strowger system as standard for automatic exchanges.

It was at this time that the idea of the Director was conceived to provide the Strowger System with digit-storing and translating facilities without the need for introducing any basically new type of apparatus. This was welcome news to the British Post Office because it meant, among other things, that their engineers and operating and maintenance personnel, already familiar with the Strowger system, would not be compelled to familiarize themselves with a new system. Furthermore, it would permit continuation of the Strowger system in all exchanges, from the smallest to the largest.

The development of the Director rapidly proceeded to the point where it could be demonstrated as a thoroughly capable piece of equipment for providing a telephone system with digit storage, translating and sending features. The Director was not adopted by the British Post Office until their engineers had witnessed a series of complete demonstrations and had imposed upon it full service tests, thus satisfying themselves in every way that the Director would meet all telephone service requirements of the largest metropolitan areas. With the adoption of the Director, the British reversed their previous decision and cancelled the order for the trial installation of the power-driven system for which they had previously contracted. The first complete demonstration of the Director system was made for the British engineers in the Automatic Electric Laboratories in Chicago in 1924. It was further tested under actual service conditions in London.

This important policy decision by the British Post Office was officially announced in a paper prepared and delivered by Colonel T. F. Purves, O.B.E., M.I.E.E., engineer-in-chief to the British Post Office. This paper was delivered before the Institution of Electrical Engineers in London on March 5, 1925, and is an official document of that institution.

Since there was to be a period of approximately two years before the conversion of the London service would be actively under way, the first Directors, manufactured by Automatic Electric Company, Chicago, were installed in the Havana network of the Cuban Telephone Company to provide service over tandem trunks with universal numbering.

The installation of Directors at Havana in 1924 solved a trunking problem which had confronted the telephone company for some years. Several of the offices in one section of the city were geographically located more or less in line with each other. The central office farthest removed from the city proper served the suburban area of Marianao. The Marianao office up to this time had been operated as a separate automatic unit, and the Marianao telephone numbers were not included as a part of the universal numbering plan used throughout the remainder of the network.

This departure from the universal numbering plan was adopted because of the expense of the cable and equipment that would otherwise have been required to provide separate groups of trunks from Marianao to all other offices in the network.

In sacrificing a universal numbering plan, the Marianao subscribers were obliged to prefix an extra digit when dialing numbers in any of the other offices. Thus all outgoing calls from Marianao, regardless of the office to which they were destined, were carried as far as the Vedado (mother) office over one common group of trunks. Calls to the Marianao office from other offices in the network were likewise carried from Vedado over a common trunk group.

By the time the development of the city had made it necessary to install an additional office to serve the rapidly growing community of Buena Vista, between the Vedado and Marianao areas, the Director had become available, and the features it provided were readily recognized by the telephone company engineers as a remedy for the Marianao trunking problem.

What the Director accomplished, in effect, was to provide the Marianao subscribers as well as subscribers of the new Buena Vista office with numbers conforming to a universal numbering plan which applied throughout the entire network. This

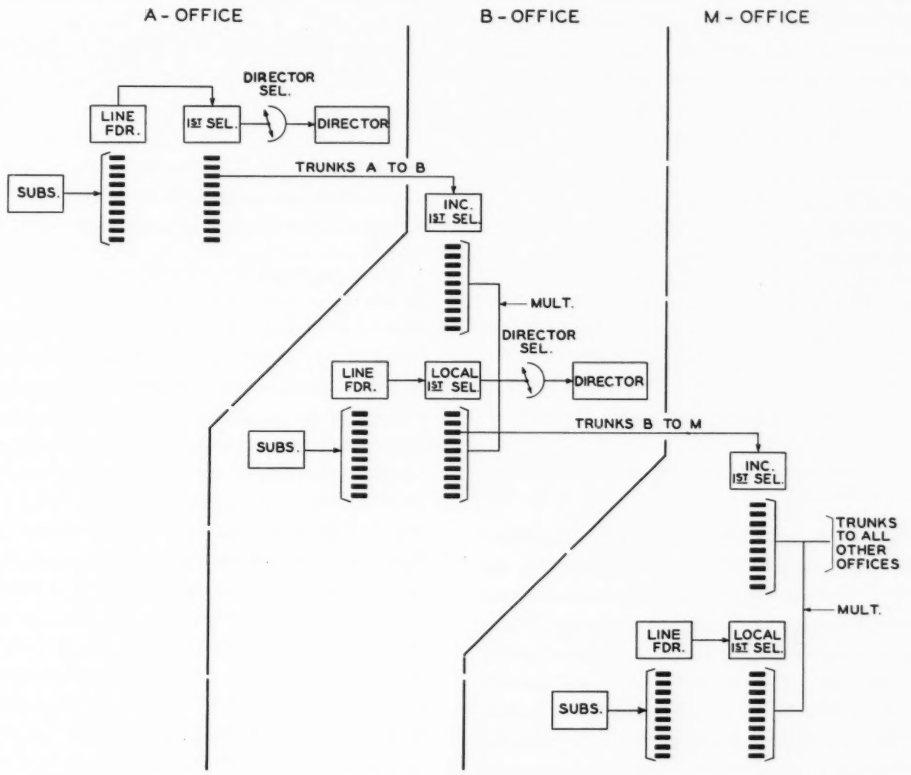


Figure 1. Application of the Director in a simple tandem trunking network.

it did by automatically prefixing the required digits to the numbers dialed to reach the subscribers in all other offices, thus relieving the subscribers in these two offices of the necessity for adding prefixes themselves. But this was not the only accomplishment, since the Director permitted service to the Buena Vista and Marianao offices on a tandem trunking basis, without the need for additional groups of inter-office trunks.

This application of the Director to the Havana network has been related in some detail because, while it is a simple example, it clearly illustrates the sort of improvement and economy the Director can effect in any network involving tandem trunking.

It may be safely assumed that the two schools of thought on the preferred method of trunking between the offices of large multi-office telephone networks referred to early in this article are still somewhat in evidence today. But it is also clear that those who, in the beginning, advocated the use of a storage and translating system for both large and small cities have moderated their point of view.

One step in the direction of moderation by this group has been to realize that it is unnecessary to provide a digit storing and translating system in the initial installation of automatic equipment in a city, the telephone network of which is not sufficiently large to require these features. This policy will permit the installation of a conventional Strowger system without storage and translation

features, because these features can be provided and the system extended to any desired size as and when conditions require, and consistent with the continued development of a universal numbering system regardless of the ultimate population. The technical and monetary advantages of a system with these flexibilities are obvious.

The reason for this is that the Director can be added to an existing network as readily as it can be incorporated in a new network. Thus its use may be deferred until such time as growth of the network requires the service features which the Director provides. The Strowger system is unique in this respect. Practically all other systems providing digit storage and translating facilities are so designed that such facilities are needed to handle local switching functions as well; thus they must be an inherent part of any such installation from the beginning.

The Director serves many functions in telephone networks, but one of the most important is its ability to direct calls between the offices of a multi-office network over both preferential and alternate trunk routes. The desirability of this feature can be readily appreciated from the savings effected in trunks between offices, since it makes possible the use of large trunk groups between certain offices and smaller trunk groups between other offices, with the further advantage that it is possible to select or determine in advance the route by which a call will be forwarded to its destination.

A typical tandem network is shown in Figure 1, which illustrates the simplicity with which the Director can be introduced into a network using Strowger automatic equipment. In this network there are three offices, designated as offices *M, B,* and *A* respectively. Office *M* is a main office in the network, and has separate groups of trunks to and from all other main offices. Offices *B* and *A* are satellites of office *M*, which is sometimes referred to as the "mother" office.

The subscriber numbers for each of the three offices are "universal"—that is, the number to be dialed to reach any given station is always the same regardless of the location of the station from which the call is dialed. Although the subscribers in satellite offices *A* and *B* dial the full number of digits as listed in the directory, the Director translates the code portion of the number corresponding to office *M* and all offices beyond it to *88* in the case of office *A* and to *8* in the case of office *B*. Likewise the subscribers in offices *A* and *B* dial the full directory numbers to reach subscribers in their own respective offices, but the Director will delete the code entirely. Thus it will be seen, in this simplest of tandem trunking arrangements, that the Director saves much in trunking facilities while conforming to the use of universal numbering.

In recent years the versatility of the Director has shown up in many other ways, including the solution of switching and trunking problems in inter-toll dialing, in the subscriber dialing of long distance calls, and in the expansion of metropolitan exchanges to contiguous areas, with their requirements for universal numbering plans and for trunking arrangements which are based on the most economic use of inter-office circuits. In recent years, Director installations have been made at San Fernando, Monrovia, and Sunland, in the Los Angeles metropolitan area, and at Park Ridge and Des Plaines in the Chicago metropolitan area. In these installations the Director performs important functions not only with respect to trunking flexibility, but also with respect to automatic toll ticketing functions on short haul toll calls.[2] In such installations, the Director, in addition to routing each call to its destination as determined by the dialed code, also controls the collection of all data (except the duration of the call) necessary to the preparation of a toll ticket.

While it is not within the scope of this article to deal with the technical aspects of the Director,[3] a brief review of its design and the components it uses may prove helpful. The Director is con-

(Continued on page 112)

2. AUTOMATIC CALL RECORDING AND ACCOUNTING IN THE SATT SYSTEM. J. E. Ostline. A.I.E.E. Winter General Meeting, New York, N. Y. January, 1953. Reprinted this issue of *The Automatic Electric Technical Journal*

3. THE STROWGER AUTOMATIC DIRECTOR. Automatic Electric Company Bulletin No. 470. June, 1952.
THE UNIVERSAL DIRECTOR IN STROWGER AUTOMATIC TELEPHONE SYSTEMS. J. E. Ostline. A.I.E.E. Summer and Pacific General Meeting, Pasadena, Calif., June, 1950. Reprinted by Automatic Electric Company as Engineering Notes 2027.

AUTOMATIC CALL RECORDING AND ACCOUNTING IN THE SATT SYSTEM*

By J. E. OSTLINE

***SYNOPSIS:** Origin of toll dialing—universal numbering and the Director—subscriber toll dialing and the SATT system — station identification—recording and tabulation of data — accounting methods — automatic bill processing.*

WHEN the first automatic telephone office was placed in public service at La Porte, Indiana, in 1892, "automatic switching" and "subscriber dialing" became established facts.

During the years following this notable event in the history of telephone communication, Automatic Electric Company through constant research and development of switching equipment and operating methods expanded the field of automatic switching from local exchange areas to suburban and toll networks. By 1910 "operator toll dialing" was introduced whereby originating toll operators were enabled to complete calls to automatic stations in distant towns by "toll dialing."[1] Operator toll dialing was then expanded to provide switching of toll circuits through tandem offices and switching centers. During the period from 1920 to 1940, several regional automatic toll switching networks were established in various parts of the United States and Canada.

Although during that period operator toll dialing became an accepted method of toll switching, "subscriber dialing" of toll calls was not as yet available for several basic reasons, some of which were:

(a) The "numbering plans" used by operators were not universal and therefore not suitable for public use.

(b) If a universal numbering plan for toll switching had been available, "common control" switching equipment would have been required to make use of it.

(c) All toll calls had to be recorded (ticketed) for billing purposes. This is one of the functions performed by toll operators.

*A paper presented at the Winter General Meeting of the *American Institute of Electrical Engineers,* at New York, N. Y., January, 1953. Reprinted by permission.

The Director

With the introduction of the Director[2] in 1923 for the London, England, metropolitan area network "universal numbering" and "common control" operation became available for Strowger (step-by-step) automatic switching in local exchange networks. The Director also made available a number of other controls, and thus it became possible to design equipment suitable for subscriber dialing of short haul and long distance toll calls with automatic call recording.

Subscriber-Dialed Automatic Toll Switching

In 1937, Régie des Télégraphes et des Téléphones (Belgian Telecommunication Authority—R.T.T.) requested Automatique Electrique, S.A. (Belgian affiliate of Automatic Electric Company) to present plans for subscriber national toll dialing with automatic recording (ticketing) of each dialed toll call. As a basic part of this undertaking, the R.T.T. had established a nationwide area "code" numbering plan (Figure 1.).

The various common control facilities available in the Director provided the solution for all phases of this request, including automatic call recording (ticketing) with cost computation for each call (Figure 2.). The first installation of this system was made at Mons, Belgium, where it proved entirely satisfactory. A similar installation was placed in service at La Louvière in 1950[3].

Figure 1. Map of Belgium showing national numbering plan areas with codes.

Further Developments

After the completion of the Belgian automatic toll ticketing plan in 1938, research was continued further to expand the automatic toll switching and call recording facilities contained therein. This resulted in a design which contained the following added facilities and methods of operation:

1. Detector (identifier) operation was arranged to provide subscriber dialing for party line subscribers on lines having up to five stations.

2. Central office toll call recording was arranged to permit the introduction of "punched card" accounting techniques, thereby making available complete automatic bill processing and accounting of toll messages.

The system resulting from the foregoing development is now referred to as the SATT (Strowger Automatic Toll Ticketing) system. When used with punched card accounting, this system is *completely* automatic from the dialing of toll calls by a subscriber to the printing of the bill for such calls.

A small trial unit containing most of the facilities in this system was installed in an office in the Los Angeles metropolitan network in 1944. Since that time SATT system facilities have been incorporated in several automatic central offices in the Chicago and Los Angeles metropolitan areas, thus providing "subscriber dialing" of short haul toll calls.[4]

Demandeur	= CALLING SUBSCRIBER
Demandé	= CALLED SUBSCRIBER
Date	= DATE
Heure	= TIME
Tarif	= TARIFF
Durée	= CONVERSATION TIME IN MINUTES
PrixTotale	= TOTAL COST

Demandeur	Demandé	Date	9090
23745	02446070	15/3	
Heure	**Tarif**	**Durée**	**Prix Total**
12.1	6.00	15	30.00 4

Figure 2. Automatic toll ticket.

The "subscriber dialing" range will eventually cover the entire nation when the facilities of the gigantic Bell System project now in progress, generally referred to as "nationwide automatic switching,"[5] become available to local and regional automatic networks. When this time arrives, offices having SATT facilities will find themselves prepared to take full advantage of subscriber "national" toll dialing.

This paper describes in outline the equipment and the automatic call recording (ticketing) and accounting (bill processing) methods used in the SATT system.

SATT Components and Functions

SATT (Type A) facilities are provided when the following basic components are added to Director-controlled local exchange equipment:

1. Call recorder.
2. Detector
3. Ticketer
4. Tabulator and Tape Perforator
5. Dater-clock

The method of arranging the foregoing SATT units in a Director office is shown in functional block diagram form in Figure 5.

Call Recorder

This unit is composed of relays and rotary switches and is added to each Director. Its function is to "assemble" and "transmit" to the ticketer the following data for each toll call:

1. Calling station terminal (connector) number
2. Class of service
3. Called station directory number
4. Rate index
5. Director identity number

The foregoing data is transmitted to a ticketer in "codel" code pulses when a toll connection is established.

Detector

The detector is composed of relays, rotary switches, and "neon" lamps. Its function is to

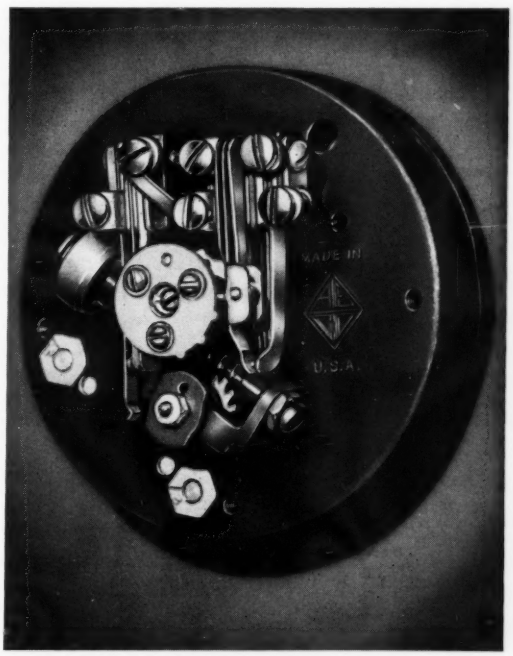


Figure 3. Identity dial.

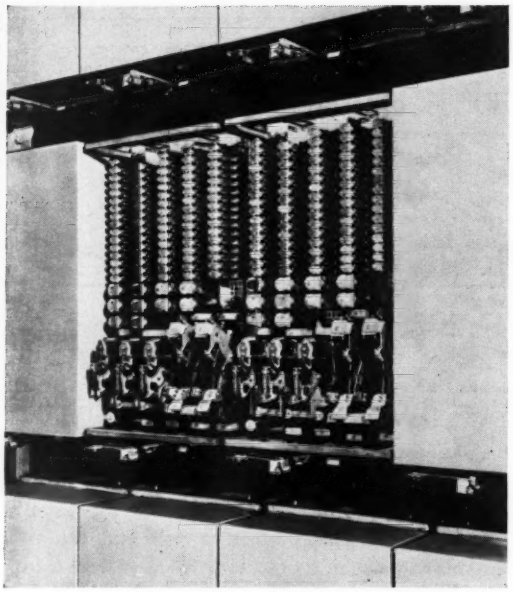


Figure 4. Two ticketer units.

"detect," under the control of the call recorder, the terminal (connector) number of a station making a toll call. This unit is common to each exchange. The operating time for each "detector cycle" is about 100 milli-seconds.

Ticketer

This unit is composed of relays and rotary switches (Figure 4). The function of a ticketer is to store "ticket data" transmitted to it from a Director and to record conversation time when a called station answers. This call timing facility consists of a self-contained unit, which always starts from a zero position, thereby eliminating fractional errors resulting from fixed time pulses. A definite timing delay is also provided to permit a calling station to check if the correct called station has been obtained. This delay can be adjusted in one second steps from 3 to 10 seconds as desired by the operating company.

Storage of "conversation time" is provided up to 5 hours. If a toll connection is kept established beyond this period, a supervisory trunk automatically extends the call to an operator for observation and action.

Tabulator

Each tabulator is a unit composed of relays and rotary switches. The function of a tabulator is to "tabulate" call data received from a ticketer, to add thereto the calling office code, tabulator identity number, date and clock time, and finally to produce a perforated tape record of each completed toll call.

Permanently associated with each tabulator is a tape perforator similar to those used in telegraph services. Standard perforator tape is used.

Each tabulator contains "strapping" facilities into which the "code" of the office unit in which it is located and the identity number of the tabulator are "strapped."

By a similar facility, "ticket items" can be transmitted to the tape in any sequence desired by the operating company when manual accounting by tickets is used. Regardless of the item sequence, tape perforation occurs in reverse order. After all items are recorded, the tabulator adds a "start" symbol. This arrangement permits the use of the tape from the "outside" of a storage reel when final accounting records are made, thus avoiding rewinding. As indicated under "SATT SYSTEM OPERATION," the initial record data of incompleted toll calls is always "wiped out" when the calling station hangs up. Therefore, the only recordings in the tape will be those of completed calls. Each call recording requires about three inches of tape.

Dater-Clock

This unit is common to all tabulators in a central office and provides the date and clock time for each completed toll call. Clock time is expressed in "Navy" figures—the 24 hours of each day being numbered continuously instead of in two twelve-hour cycles. It operates on a four-year cycle so that the extra day in leap year is automatically provided for.

Station Identity Dial

A basic facility in the provision of SATT service to party line stations is provided by a "station identity" dial (Figure 3). This is a standard dial to which has been added a pulsing arrangement which identifies up to five stations on a party line. This facility does not alter the normal mechanical structure or function of the dial.

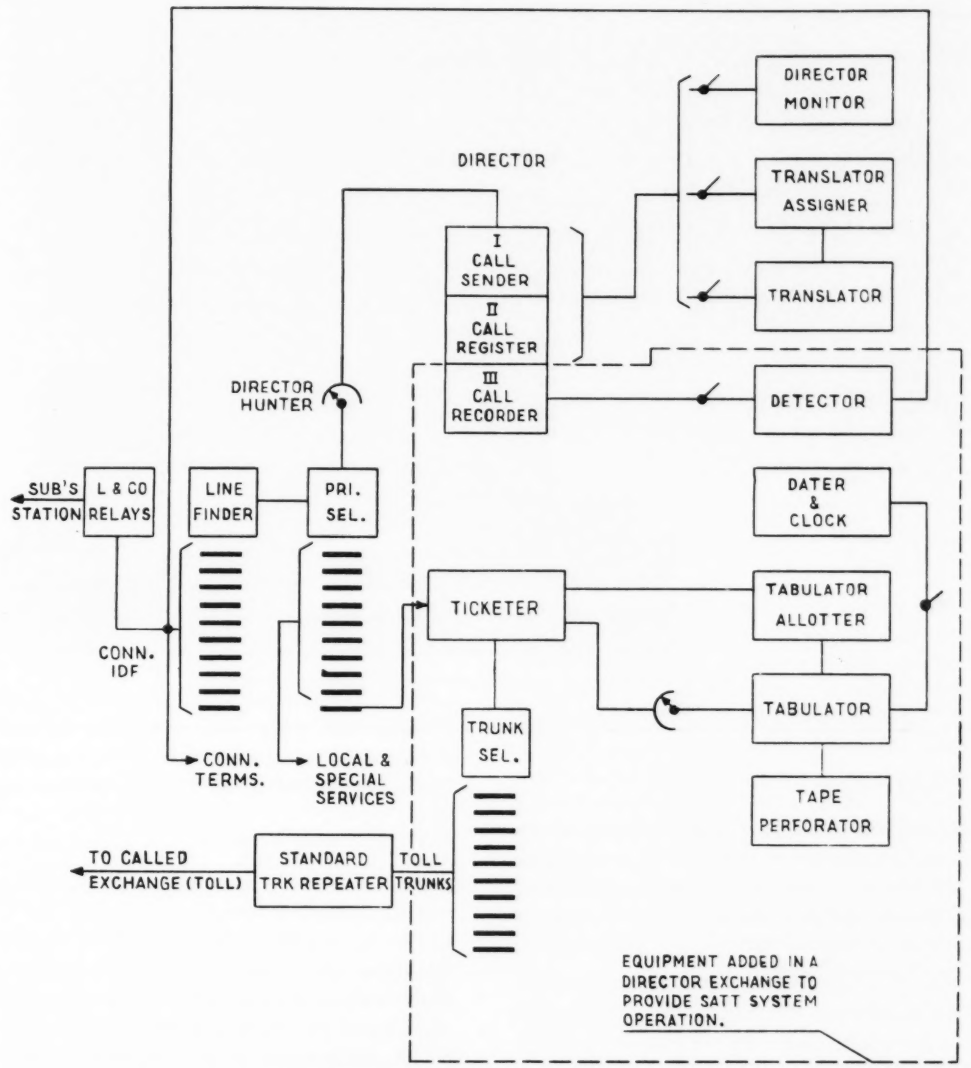


Figure 5. Central office SATT system. Functional block diagram.

In operation, this dial transmits "station identity" pulses during each "pull," but these pulses are "inserted" between the regular dial pulses and do not in any way interfere with them. The Director contains a facility which records this station identity code. If the call is local, this recording is not used, but if the call is "toll," it is transferred to the call recorder (Figure 5). Therefore, when a call recorder tests for a calling station terminal number, it already "knows" what service a calling station has, i.e., individual line or party line. If party line, it knows which station of a maximum of five on the line has dialed the call. It will, therefore, make the terminal number detection (identification) test accordingly.

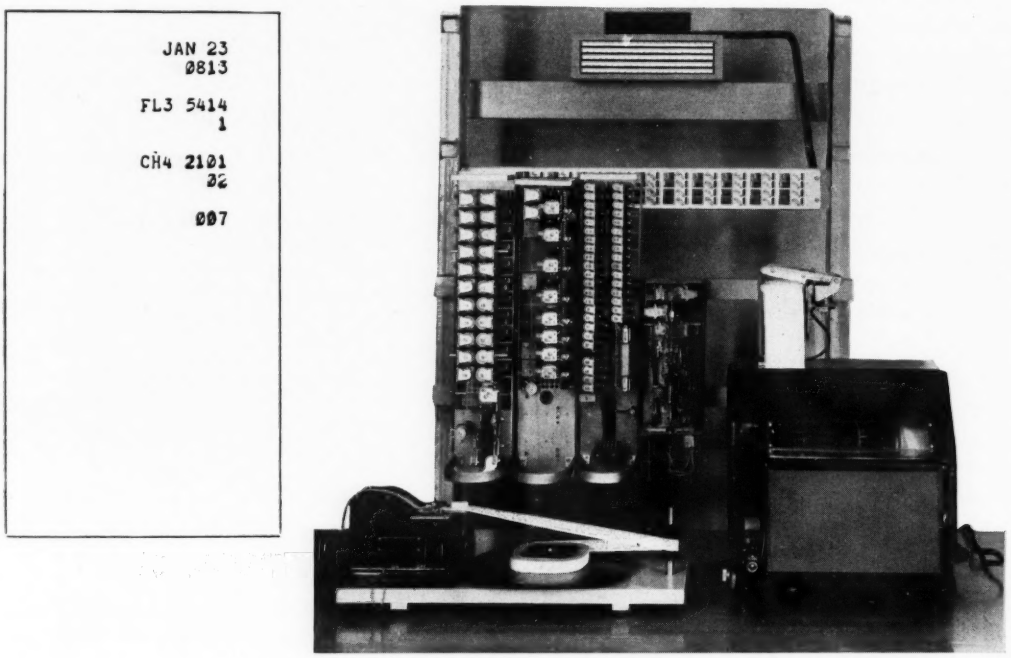


Figure 6. Tape reader and ticket printer, with typical toll ticket.

SATT System Code

All call data transmitted and recorded in the SATT system consists of numerals in a code pattern referred to as the "codel" code. Each digit is represented by combinations of four elements for transmission pulses, storage relays or tape perforations as shown in Figure 9.

When data from the call recorder is "pulsed out" to the ticketer, each digit is composed of four "high and low" pulses. When digits are stored on relays, a codel relay group is used with the relays marked W, X, Y, Z, which are operated for each digit as indicated in the table. The tape code is a "four channel" type with perforations in the same relative positions as the "high" pulses in each code digit (Figure 8). When a tape is processed, the start symbol is used to start transfer of tape data into either a ticket printer (manual accounting) or into a "card punch" (automatic accounting). The blank symbol is used to fill in the third office code digit space when combined "2-4" and "2-5" numbering is used in an exchange area.

SATT System Operation

The following section deals with the automatic call recording (ticketing) facilities in the SATT (Type A) system. The methods of establishing subscriber dialed speech connections and other functions are not described except as required to explain call recording operations. The outline of SATT components in the preceding section describes most functions of each component in more detail.

Call Recording From Party Line Stations

The initial versions of the SATT system provided subscriber dialed toll service for "individual" line subscribers only. Owing to the fact that relatively large portions of subscribers in telephone exchanges in the U. S. A. use "party line" service, it became apparent that in order to make full use of the service and economic advantages of sub-

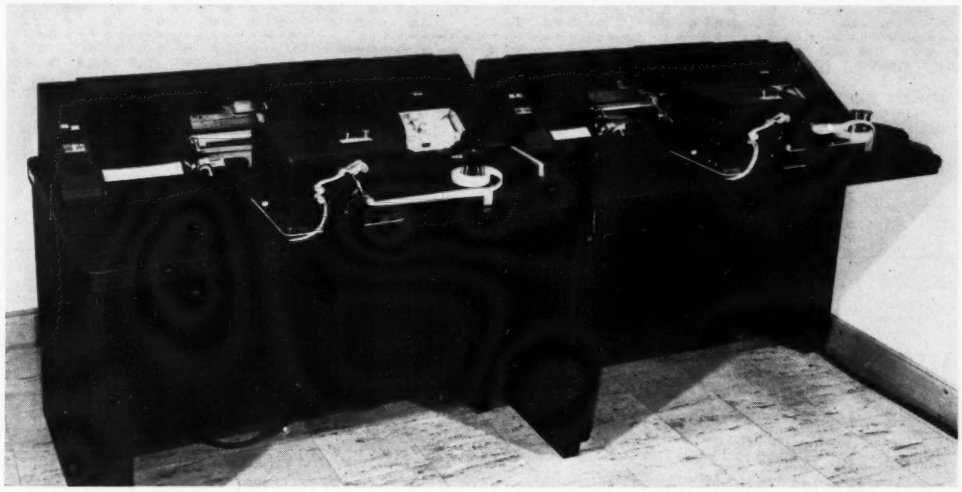


Figure 7. Card punch with tape-to-card control unit.

scriber dialing which are available in the SATT system, it had to be arranged to provide service for party line as well as individual line stations.

Surveys of the independent operating field indicate that in most cases where party line service is provided, it is of the four party type, although in a comparatively few cases, five party service is also provided. The SATT equipment is therefore arranged for completely automatic individual and five party terminal-per-station automatic call recording.

Automatic Recording of Call Data

Whenever a call is initiated in an automatic exchange containing SATT system facilities, it is extended to a Director which is composed of several "common control" units (Figure 5). After receiving dial tone, the calling subscriber dials the directory number of the called station. This is "stored" in the call register. If the office code portion of this number indicates that the terminating office is a toll point, the resulting "directive" (translation) obtained from the common "translator" will always establish a trunking path to the called office via a "ticketer." This directive will also "alert" the "call recorder." This unit of the Director "assembles" the major portion of the toll call data.

The call recorder upon being alerted first of all receives from the call register an indication as to whether the calling station is on an individual or party line, and if on a party line, which particular station on that line has initiated the call. The call recorder now "calls" for the common "detector" (identifier). As soon as the detector responds, the call recorder "informs" the detector in which particular group of station terminals it should search for the calling station. In the case of an office providing individual and five party service, this means one of six different number groups. The detector then "tests" in the indicated group for the terminal number of the calling station, and transmits this number to the call recorder where it is stored. The detector then releases.

The call sender unit of the Director will be establishing the desired connection while the foregoing cycle in the call recorder takes place. As soon as the call recorder has "dismissed" the detector, it will start sending the ticket data now available in the Director to the ticketer where it is stored. This transmission, which is in "codel" code, takes place simultaneously with the establishment of the trunk (speech path) connection to the called office.

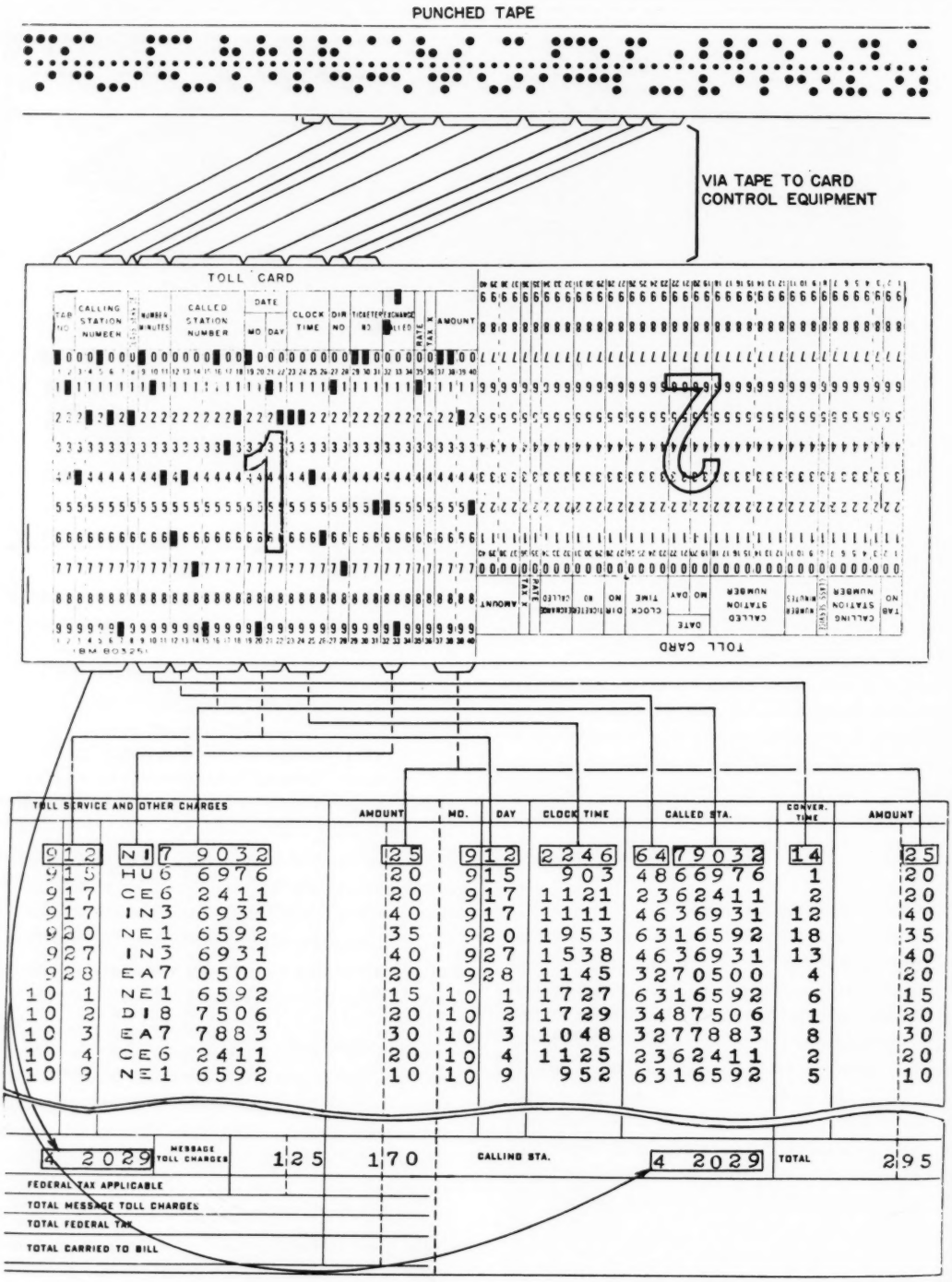


Figure 8. Block diagram of punched card tape-to-bill process.

The call data transmitted to the ticketer from the call recorder consists of:

1. Calling station terminal number
2. Called station directory number
3. Rate index
4. Class of service

In addition to these call items, the call recorder also transmits the "identity number" of the Director handling the call.

After a connection has been established to the called central office terminal, the Director releases. The calling station is now connected to the called station connector terminal via a ticketer in the originating office, and the call (ticket) particulars accumulated up to this point are "written up" (recorded) in the ticketer. At this stage, the call may result in a busy signal or "no answer." Should this occur, the calling subscriber replaces the handset, whereupon all equipment involved in the connection is released, and the accumulated call data is "wiped out."

Timing of Conversation

When a call is answered by a called station, timing of conversation begins after a fixed delay to permit the calling subscriber to ascertain that the correct called station has been obtained. The conversation time is recorded in minutes.

Tabulation of Call Data

When a conversation is completed, the calling subscriber replaces the handset. This results in the following operations:

1. All switching equipment and trunks held by the call are released except the ticketer which "locks up" and makes itself busy to other calls.
2. The ticketer "calls" for a tabulator out of a common group via a tabulator assigner. The assigned tabulator connects itself to the calling ticketer.

The ticketer now transmits the following items to the tabulator where it is stored:

1. Calling station terminal number
2. Called station directory number
3. Rate index
4. Class of service
5. Conversation time
6. Director identity number
7. Ticketer identity number

At the end of this transmission the ticketer is released, thereby removing its "busy" condition.

Final Call Data Recording

As soon as a tabulator has received the call data from a ticketer, its associated tape perforator starts to perforate the data into its tape. Such data may be, for instance, in the following sequence:

1. Ticketer identity number
2. Director identity number
3. Date
4. Clock time
5. Called station directory number
6. Conversation time
7. Rate index
8. Class of service
9. Calling station directory number
10. Tabulator identity number

To this series of items is always added a "start" symbol. This is followed by the restoration to normal of all tabulator components thus making the tabulator available for another call. The punched tape is automatically wound up on a storage reel from which it is removed periodically and forwarded to an accounting center for processing.

SATT Accounting (Bill Processing) Methods

General

A basic requirement in connection with the provision of short and long haul toll services to telephone subscribers is that of obtaining a "ticket" or call record for each completed call in order to enable the telephone company to bill the sub-

Digit	PULSE POSITION 1	2	3	4	RELAYS OPERATED W	X	Y	Z	TAPE CHANNEL 1	2	3	4
1	H	H	L	L	*	*			•	•		
2	H	L	H	L	*		*		•		•	
3	H	L	L	H	*			*	•			•
4	L	H	H	L		*	*			•	•	
5	L	H	L	H		*		*		•		•
6	L	L	H	H			*	*			•	•
7	H	L	L	L	*				•			
8	L	H	L	L		*				•		
9	L	L	H	L			*				•	
0	L	L	L	H				*				•
Start									•	•	•	•
Blank										•	•	•

Figure 9. Functional chart of "Codel" code pulsing, storage, and tape recording.

scriber for this service. Therefore, in automatic networks without automatic toll call recording facilities, subscribers desiring toll call connections are required to dial an operator so that the telephone company may obtain the data required to bill subscribers for such calls. Otherwise these connections could in many cases be "subscriber dialed" the same as local calls.

A manual toll ticket as prepared by an operator, generally contains the following data:

1. Date and clock time
2. Calling station directory number
3. Called station directory number
4. Conversation time

Items 1, 2, and 3 are recorded when the call is initiated and item 4 when the call is completed.

Completed toll tickets are forwarded to the accounting or commercial department of an operating company where they are put through a routine referred to as "bill processing." This routine is to a large extent a manual procedure, consisting primarily of computing the cost of each call from the ticket data, adding federal (and sometimes local) taxes, etc. These calls are then transcribed to and added up on a "toll service statement" which is attached and added to the regular monthly bill. The amount of detail shown for each call is usually prescribed by the state or federal regulatory commissions under whose jurisdiction the telephone company operates.

Some of these regulatory bodies require all toll calls to be billed in more or less detail, while some permit calls within certain metropolitan areas to be reduced to "message-units". All message units are then added and "bulk-billed" for each billing period as one item without detail.

In detail billing each call may show not only the called station, the date and total cost, but may also show rate and conversation time to permit subscribers to check each call in detail for themselves.

No matter what rules govern the manual toll billing process of an operating company, it is always a function which requires considerable organization details and manual labor. The use of various labor-saving devices has assisted in making manual accounting very efficient, but complete mechanization of this process will considerably reduce billing costs to telephone companies.

As described in previous sections, each toll call completed in a SATT system central office is recorded in a perforated tape. This tape is the equivalent of the call tickets obtained in manual operation and is therefore the primary record of each call.

Completed tapes from central offices are sent to an accounting center by mail or by other means. However, when trunk facilities are available, the tape data is also suitable for transmission by wire to an accounting center. This can in many cases speed up processing operations.

To obtain subscribers' toll statements from "ticket" tapes, two methods are available: manual or automatic bill processing.

Manual Processing

When it is desired to obtain subscribers' bills from SATT tapes by manual methods, a "tape to ticket" assembly is provided (Figure 6). This assembly consists of a printer controlled by a "tape reader". This assembly prints a standard size toll ticket for each call contained in the tape. These tickets are then processed in the same manner as regular manual tickets.

If desired, this process can be made partly automatic. A unit termed a "computer" can be included with the tape reader. When this is done, the cost of each call will be automatically computed from the tape data and printed on the ticket in addition to other data.

As previously described, the tabulator can be "strapped" in such a manner as to record each item in the tape in the same sequence as used on tickets prepared by manual operators. This will avoid manual errors in processing tickets from two sources.

Automatic Processing

Automatic accounting (processing) of SATT system call data is accomplished by means of "punched card" accounting equipment. This type of equipment has proved satisfactory over many years for almost every known kind of accounting requirement.

It may be of interest at this point to relate that surveys of accounting methods by independent telephone companies have disclosed the fact that some of them are already using punched card equipment to speed up and simplify manual accounting processes. When these companies adopt SATT operation, they will therefore be able to continue using present facilities and methods by merely adding a "tape to card" unit to each card punch.

The first and basic step in obtaining printed subscribers' bills and auditing records with punched card equipment is to produce a punched card from the call data in a "ticket" tape. This is done by using a "tape to card" unit with a regular "card punch" (Figure 7). After a punched card has been obtained, it is used to control subsequent processes from which the basic end result will be a printed subscriber's bill (Figure 8). However, in this process, various other types of records are also obtained, depending on the amount and kinds of accounting data an operating company may require.

An interesting "by-product" obtainable from punched cards is toll traffic data. Computation machines can be set to sort out the particular items desired such as busy hour calls and average holding times, and from what classes of subscribers calls originate.

Conclusion

When the SATT system was designed, one of the primary aims was to use as far as possible tried and proved circuitry arrangements, and only such components as had been proved satisfactory in other fields and were commercially available.

Thus the system described herein contains common control (Director) circuitry which has been used for many years in metropolitan areas. The record tape is of the same type as the message tape used in telegraph services. The "punched card" accounting equipment is also a well-known and proved equipment used in many commercial fields.

SATT system facilities are basically of such a nature that they can also be provided for non-Director step-by-step automatic central offices of all types and sizes, but special numbering and dialing methods must then be employed for subscriber dialed toll traffic. However, the end result is the same in each office; i.e., each completed subscriber dialed toll call is recorded in a ticket tape in exactly the same manner as in a Director-controlled office.

One interesting fact is already becoming apparent. Operating companies now providing SATT system service have found that mechanical

accounting is not only a very desirable method as compared with manual processing, but also more economical[6].

As automatic telephone switching eventually became the accepted mode in providing "local" telephone service, subscriber dialing, automatic call recording and automatic accounting will without a doubt be the accepted mode in providing regional and national toll telephone service in the future.

Acknowledgment

Grateful acknowledgment is made to my Automatic Electric Company associates and Mr. R. F. Stehlik of Automatique Electrique, S.A., Antwerp, Belgium, for suggestions and assistance in preparing this paper.

Bibliography

1. AUTOMATIC SWITCHING OF TOLL TRAFFIC. Arthur Bessey Smith. *Journal Western Society of Engineers,* Chicago, U.S.A. Vol. 29, No. 2, February, 1924.

2. THE POST OFFICE AND AUTOMATIC TELEPHONES. Col. T. F. Purves. *Journal Institution of Electrical Engineers,* London, England. Vol. 63, No. 343, July, 1925.

3. LA LOUVIERE AUTOMATIC NETWORK OF THE BELGIAN TELEPHONE SYSTEM. R. F. Stehlik, *Automatic Electric Technical Journal,* Chicago, U.S.A. Vol. 2, No. 4, January, 1951.

4. APPLICATION OF STROWGER AUTOMATIC TOLL TICKETING AND PUNCHED CARD ACCOUNTING IN METROPOLITAN NETWORKS. J. T. Naylor. *Automatic Electric Technical Journal,* Chicago, U.S.A. Vol. 2, No. 2, February, 1950.

5. AUTOMATIC SWITCHING FOR NATIONWIDE TELEPHONE SERVICE. A. B. Clark and H. S. Osborne. *Electrical Engineering,* New York, U.S.A. Vol. 71, No. 9, September, 1952.

6. AUTOMATIC TOLL TICKETING IN ACCOUNTING. H. A. Hansen. *Telephony,* Chicago, U.S.A. Vol. 141, No. 17, October 27, 1951.

THE PREPAY PAYSTATION REPEATER

By KARL F. STEINHAUER

***SYNOPSIS:** History and description—enforcing deposit—pulse repetition—delayed collect feature—collection—refunding—CLR calls—calls to the paystation—common equipment.*

IN the April 1952 issue of *The Automatic Electric Technical Journal* the author dealt with the design and operation of paystations for ten-cent service, with particular emphasis on subscribers' station equipment. The present article emphasizes central-office equipment used alike for five-cent and for ten-cent local prepayment service.

A customer calling from a prepay paystation lifts the handset. Depending upon the preference of the operating telephone company, he may or may not hear dial tone before depositing the required coin or coins (to protect the customer against loss of his money at a time when the line might be dead, Automatic Electric Company recommends that dial tone be given *before* coin deposit is required). He cannot dial effectively until after deposit of the coin or coins required for a minimum-charge local call. The device which blocks the call until payment has been advanced is the *prepay paystation repeater.*

History and Description

The prepay paystation repeater was designed by Mr. John Wicks of Automatic Electric Company in 1920; and a U. S. patent was applied for May 23, 1921 and granted October 11, 1927. The first such equipment was installed during 1921-1922 at Lethbridge, Alberta, Canada. Mr. Wicks' 1920 basic design was sound; only minor improvements have been required in the intervening 33 years. The circuit-minded reader will be intrigued by the techniques applied in paystation equipment.

The prepay paystation repeater blocks a call until payment has been advanced. After money has been deposited, it repeats dial pulses, and causes a switch train to be built up which connects to the called line. When the caller hangs up, the repeater either refunds or collects the deposit, depending whether the called party failed to answer or was busy, or answered the call.

Figure 1 shows two prepay station repeaters. The one at the left has the minimum number of relays; the one at the right has two additional relays for "delayed collection" and is the present standard of Automatic Electric Company.

Figure 2 compares a paystation switch train with a regular switch train, and illustrates the position of the paystation repeater, namely, between the linefinder and the first selector. Figure 2 illustrates also that since the prepay paystation repeater is a device to block calls until money has been deposited, (except in occasional instances where "adapters" are used) prepay paystation lines can-

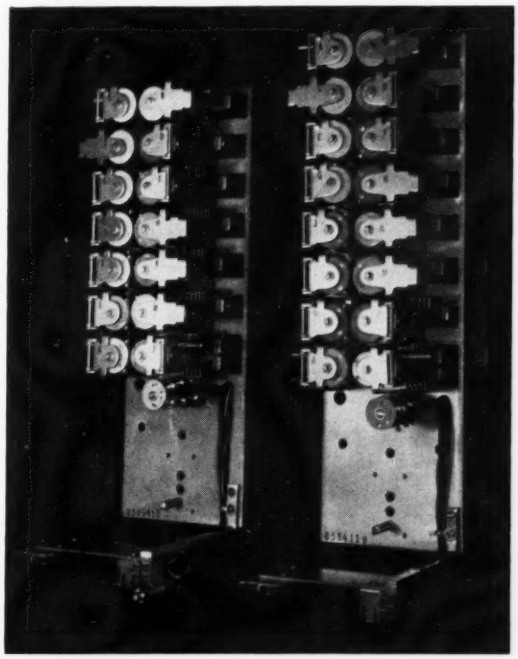


Figure 1. Typical paystation repeaters. The one at the right has the "delayed collection" feature described in this article.

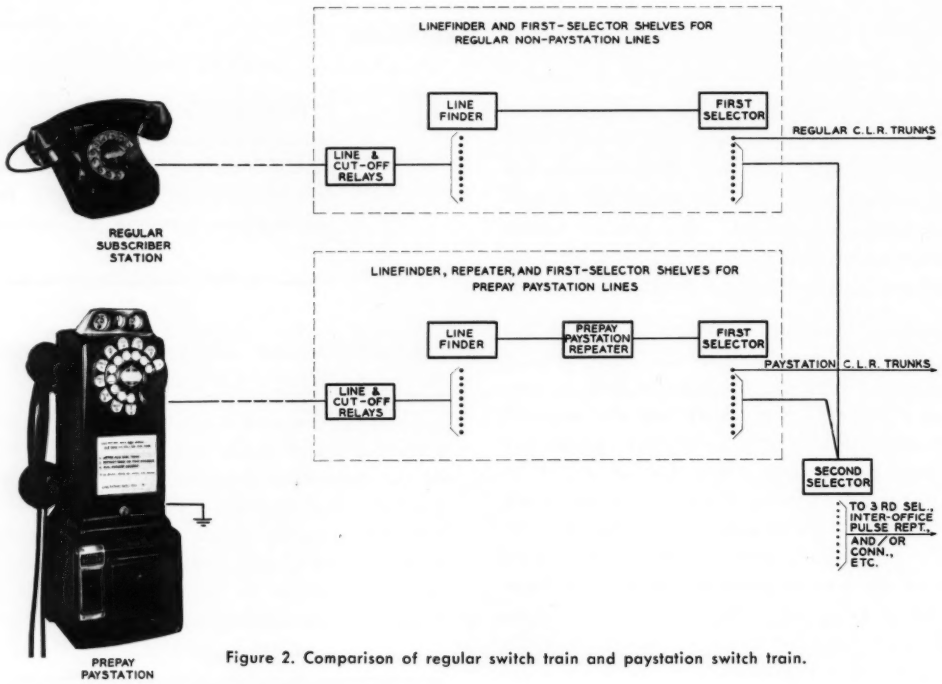


Figure 2. Comparison of regular switch train and paystation switch train.

not be mixed in a linefinder shelf with regular lines; they must be served by separate linefinder shelves. Lastly, Figure 2 shows that linefinder and first selector interconnections carry the paystation-nonpaystation segregation through to separate first selector shelves whose "Operator" levels signal the toll board via distinct groups of CLR trunks: one for regular subscribers who can be billed for their tolls, the other for paystation customers from whom collection must be made at the time of the call.

Circuit Operation

Enforcing deposit

Although basically this article is about central-office equipment, it is inevitable that it must also mention frequently the paystation telephone instrument apparatus which controls, and is controlled by, the paystation repeater. Figure 3 shows a prepay paystation "coin relay" in its normal position. The ground-connected coin-relay coils terminate at the leftmost or make spring in the make-before-break combination, at which point their circuit is open. The original Fosberg 1911 design for manual service had only this make contact. An improvement by Mr. George A. Long, patented July 5, 1921, added the break contact in the center of the make-before-break combination to short circuit the dial pulse springs as shown in Figure 3.

The calling customer removes the handset, closes the loop, and his line is found by a linefinder in the usual way (Figure 4). Repeater relay *L* windings are connected differentially; repeater relay *L* does not operate. Repeater relay *A* operates, operating repeater relay *B* and first selector relay *A*. Repeater relay *B* holds the linefinder, polarizes relays *J* and *R* so that they cannot operate, and cuts in relay *S* springs (*4*) as a short circuit to prevent repeater relay *A* from repeating pulses to the selector. The first selector returns dial tone, which the caller hears through wiring *Z* and

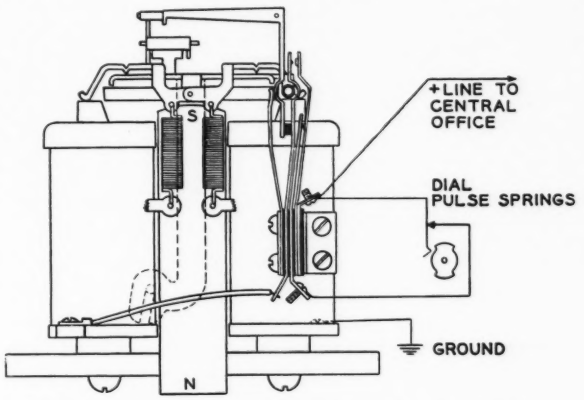


Figure 3. Prepay paystation "coin relay" in its normal position. The dial pulse-springs are short-circuited.

capacitors *N* and *P*. This assures him that the line and the equipment all are in working order and alerted to handle his call, and that he may safely deposit the charge. (If neighboring operating telephone companies do not give dial tone until *after* deposit, and the local company wishes to follow the same practice, wiring *Z* can be omitted, so that dial tone will not reach the caller until after coin deposit. Automatic Electric Company does not recommend this, however.)

As shown in Figure 4, until a coin has been deposited, the telephone dial pulse springs are short-circuited *(1)*, and the central office repeater pulse-repeating contacts are short-circuited *(4)*.

Coin deposit

When a coin is deposited it knocks down the coin-relay trigger, permitting the top arm or "switch lever" to drop. This rearranges the make-before-break combination as shown in Figure 5. The short circuit is removed from the dial pulse springs. The ground-connected coin-relay magnets are connected to the + line.

Figure 6 shows the complete situation after coin deposit. At *(1)* the dial pulse springs no longer are short-circuited. At *(2)* the 1020-ohm addi-

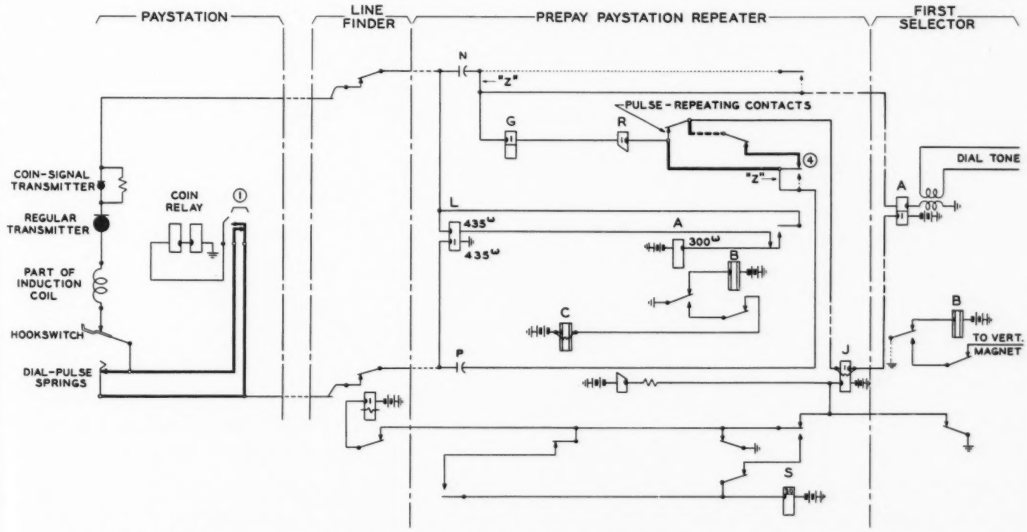


Figure 4. Calling customer has lifted the handset, but has not deposited coin. With wiring Z, customer hears dial tone. Repeater relay A pulse-repeating contacts are short-circuited by relay S contacts (4).

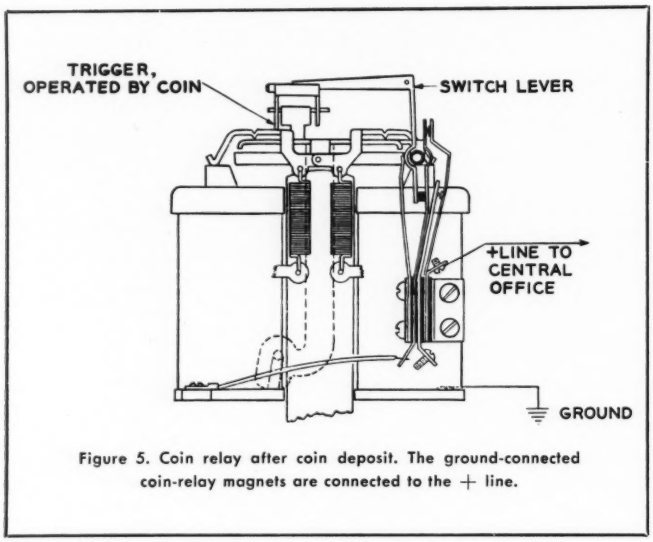


Figure 5. Coin relay after coin deposit. The ground-connected coin-relay magnets are connected to the + line.

tional path to ground shunts (and thus decreases the current through) relay *L* winding *1* and increases the current through relay *L* winding *2*. Unbalanced differential relay *L* operates and at (*3*) operates relay *S*. Relay *S* locks and at (*4*) removes the short circuit from relay *A* pulse-repeating contacts. Now, any dialing by the caller will be repeated to subsequent switches. As shown by heavy dotted lines, during each digit, relay *C* minimizes inductance in the pulsing circuits by resistively shunting relay *L* winding *1* in the in-pulse path and by removing relays *G* and *R* from the out-pulse path.

Lest it pass unnoticed, attention of the reader is called also to the separation of leads *C IN* and *C OUT*. Henceforth, only the repeater holds the linefinder (*cf.* Figure 13). Succeeding switch relay *B* keeps relays *J* and *R* polarized and unoperated.

Why pulses are "repeated"

It will be seen later that (except on calls to the telephone company business office or to the fire or police department) when the called party answers, the paystation repeater switches through and ceases to be a repeater (Figure 8). Inasmuch as the "repeater" functions require several relays and complicate the circuit, frequently it is asked: "Why can't the paystation repeater switch through right after coin deposit and allow the dial pulses to go straight through, as do the hookswitch signals after the called party answers? Why *must* the paystation repeater 'repeat'?" Figure 7 has been introduced to clarify these points.

A switch which responds directly to dial pulses from an ordinary telephone has a lone *double-wound* pulsing relay which feeds battery both to the + line and to the — line. The paystation repeater has two separate battery-feed relays: relay *L* for the + line, and *single-wound* pulsing relay *A* for the — line. The benefit gained by this is shown in Figure 7.

If a paystation were allowed to dial directly into a double-wound pulsing relay as shown in the upper diagram of Figure 7, upon deposit of the coin the paystation ground would place the coin relay in parallel with the pulsing-relay ground-connected winding. This shunt would complete the circuit for currents induced according to Lenz' Law in pulsing-relay winding 2, and would make the pulsing relay slow acting. In some cases, stepping pulses to switch magnets could be distorted to the point where connection might be made to a wrong number.

In Figure 7, lower section, we see that with separate battery feed relays for the + line and for the — line, as in the paystation repeater, if only the — line relay repeats pulses, sluggishness of the + line battery feed relay cannot interfere with correct stepping of selector and connector switches.

Called party answers

In Figure 6, with connector relay *A* polarity "normal" (positive on + line, negative on — line), polarized relays *J* and *R* could not operate.

When the called party answers, connector relay *D* reverses trunk polarity, and relays *J* and *R* operate. Relay *R* locks to lead *C OUT*, holds relay *S* and (except for relay *J* in series) switches the caller straight through to the connector. See

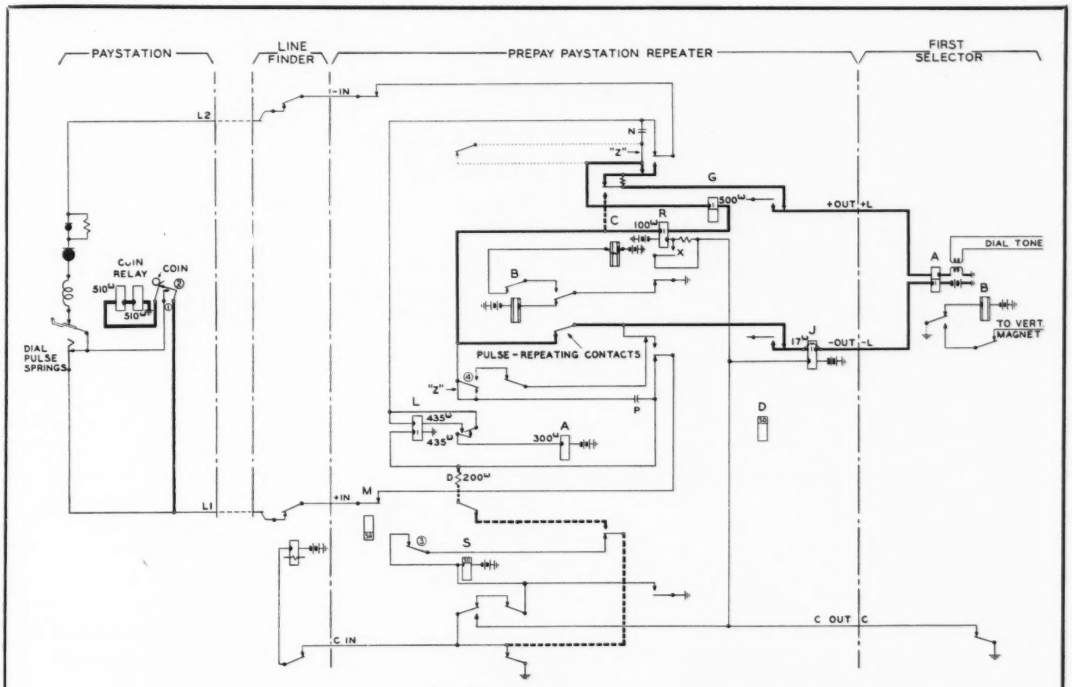


Figure 6. Coin has been deposited, putting 1020-ohm ground on + line as shown by heavy line at left. Repeater now is ready to repeat pulses via heavy lines toward right.

Figure 8. Before repeater relay *B* (Figure 6) releases, relay *H* (Figure 8) operates, and holds the linefinder (cf. Figure 13).

In Figure 8 notice that with connector relay *D* operated + *OUT* actually is negative, relay *R* connects + *OUT* to — *IN*, and the paystation hookswitch stands between — *IN* and the coin-relay ground. This is one of the important details of prepay paystation circuitry; it will be mentioned again later.

The called party having answered, we must consider charging the calling customer for the call. First, however, the paystation repeater will be cautious and will check whether the "off-hook" signal which operated relays *J*, *R*, and *H* really is the answer of the called party.

"Delayed collect" feature

Figure 9 illustrates two types of "off-hook" signal for which the calling paystation customer should not be charged. One possibility, admittedly unlikely, is erroneous momentary operation by an intercepting operator of her toll "flash" key. The heavy lines, however, depict a situation very common in flat-rate "free-service" networks. These are "free-service" networks in the sense that toll-center regular subscribers do not pay extra to call tributary subscribers and vice versa. Toll-center paystation customers, however, pay the same for a call to a tributary subscriber as for a local call; hence, the toll center outgoing pulse repeaters reverse battery to the calling line whenever an off-hook signal is received from the tributary. The few trunks to the unattended central office are reached not only by subscribers of the toll center exchange but also by the toll operators. As a result, the tributary office connectors are arranged so that they return not only busy tone but also flash busy on *all* calls from the toll center to busy tributary lines.

In Figure 8, relays *N* and *P* and a timer which

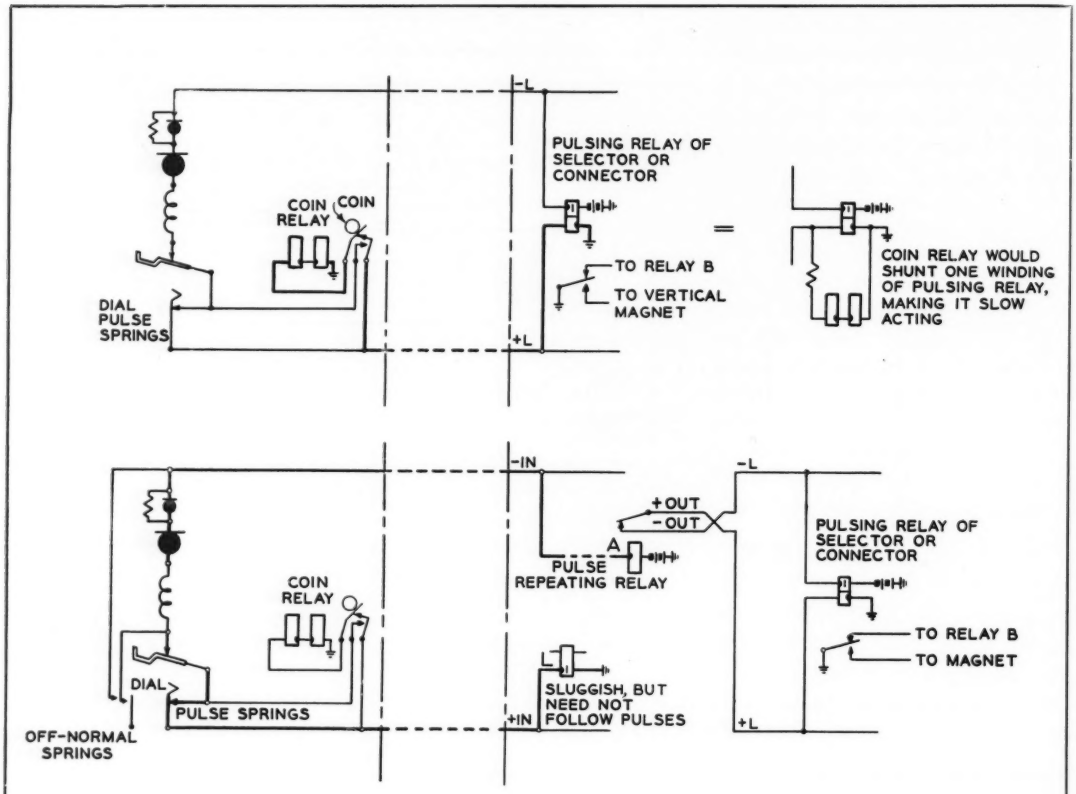


Figure 7. The + line ground makes it advisable for the paystation dial to pulse a single-wound pulsing relay, which repeats pulses to other switches.

is common to many repeaters sort the flash-busy off-hook signals from the called-party-answer off-hook signals.

Let us consider flash busy first. The first off-hook pulse operates relays *J*, *R*, and *H* as explained previously. Relay *H* starts the timer, and relay *J* connects relay *N* to the *Time Pulse* lead. After about 4⅛ seconds, ground appears on the *Time Pulse* lead, and if an off-hook signal is received from the tributary at the same time, two-step relay *N* operates its contacts *X*. About one-fifth second later ground is removed from the *Time Pulse* lead, and ground from relay *R* through contacts of relay *D* sends current through both windings of relay *N* in series, operating *N* fully. Relay *N* locks for the moment through contacts of relay *D*. Within about one-half second, however, an on-hook signal from the tributary releases relay *J*. Repeater relay *D* operates, releasing relay *N*. This cycle repeats itself until the calling customer hangs up, whereupon, relay *P* being unoperated, repeater relay *M* refunds the customer's deposit.

Called party answers—continued

As previously stated, when called party answers, relays *J*, *R* and *H* operate. Again we have relay *H* starting the timer, and relay *J* connecting relay *N* to the *Time Pulse* lead. After about 4⅛ seconds ground on the *Time Pulse* lead operates two-step relay *N* contacts *X*. About one-fifth second later removal of ground from the *Time Pulse* lead permits relay *N* to operate fully and lock. Relay *N*

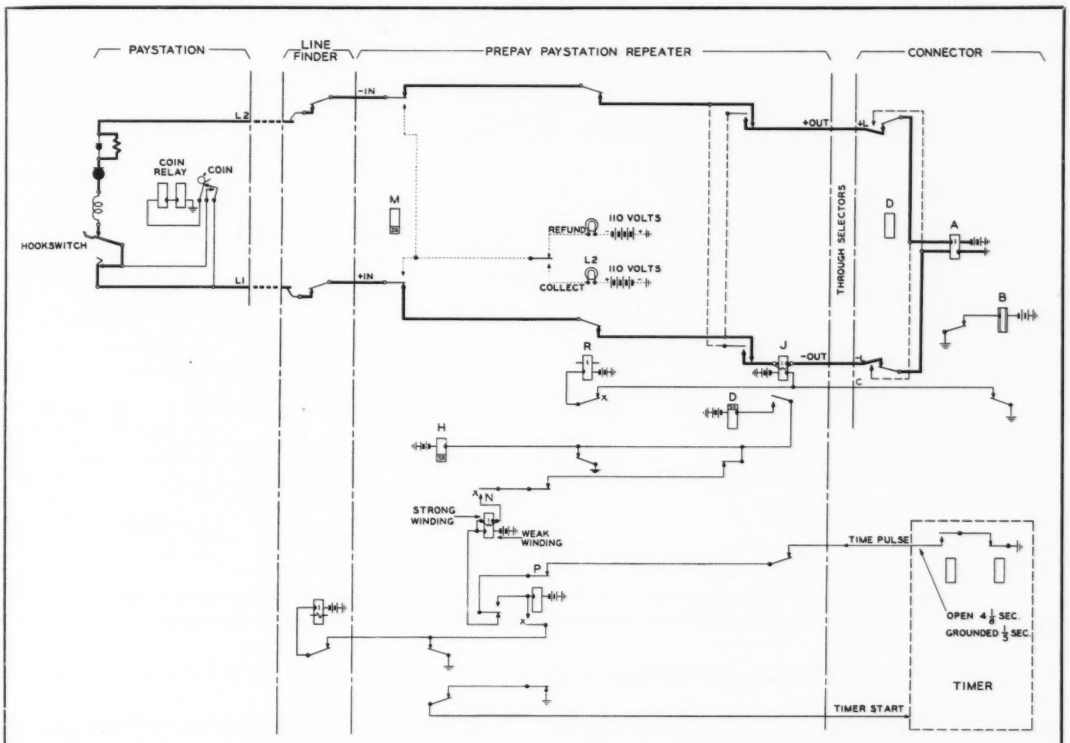


Figure 8. Circuit conditions during the *first 4 seconds* just after called party answers. Repeater has "switched through" and, except for relay *J*, has removed itself from the talking circuit. Same conditions exist also just after answer of CLR operator on long-distance calls.

transfers the *Time Pulse* lead to relay *P*. About 4⅛ seconds later the *Time Pulse* lead is grounded again and relay *P* operates, locks, stops the timer, and connects + 110 volts to repeater relay *M*. Now, when the caller hangs up, his deposit will be *collected*.

Assume called party hangs up first

Although etiquette prescribes that the called party should allow the calling party to hang up first, it will be more instructive to study the operations when the called party hangs up first.

When the called party hangs up, connector relay *D* returns trunk polarity to normal, which means that *for a moment* ground through the coin-relay magnets, *L1*, + *IN*, — *OUT*, and — *L* can hold connector relay *A* regardless of the position of the caller's hookswitch. If allowed to persist, this would be an unwholesome condition; needless to say, it is tolerated only a fraction of a second.

Release of connector relay *D* releases repeater relay *J*. Repeater relay *D* operates and offsets the polarity change from the release of connector relay *D*. Tracing Figure 8 dashed lines, we see connector relay *A* battery-connected winding *1* connected via connector unoperated relay *D* dashed line to — *OUT* and thence via repeater operated relay *D* dashed line to — *IN*, *L2*, and the hookswitch, which is as it should be.

Collection

As on other calls in most Strowger systems (and with the help of repeater relay *D*), the calling party has full control of the release of his own line.

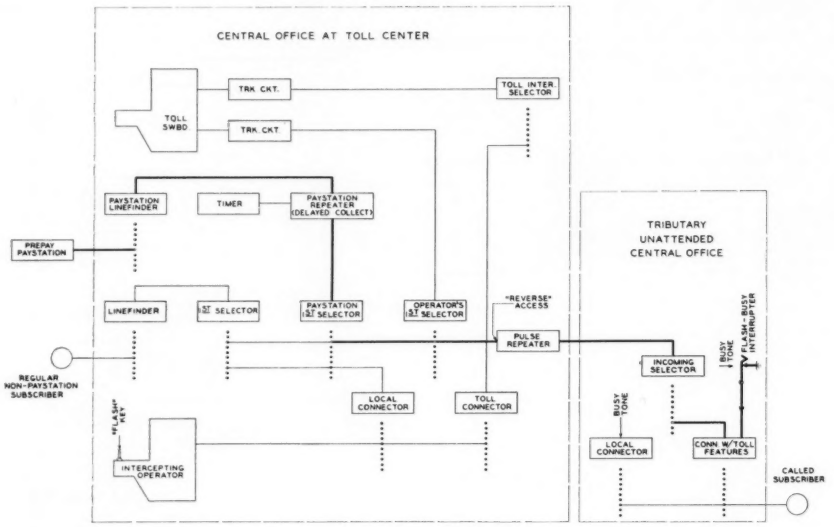


Figure 9. Typical flat-rate free-service network. Flash busy, which the tributary connectors have for the toll-center operators, makes "delayed collection" necessary in the toll-center paystation repeaters.

When the calling customer hangs up, the operations shown in Figure 10 take place. They require almost 2 seconds to complete.

A moment after the calling customer hangs up, connector relay *B* releases the intervening selectors and repeater relay *R*. Repeater relay *R* releases relay *S* and operates relay *M*. Relay *M* starts the interrupter and connects + 110 volts to the + line (Figure 10 heavy line). The coin-relay armature and relay *E* operate. The coin-relay armature moves the coin vane to allow the deposit to fall into the coin receptacle and raises the "switch lever", whereupon gravity resets the trigger, but an armature extension, called the "operating arm" (Figure 11), keeps the coin-relay coils connected to the + line. Relay *E* operates relay *K*. Relay *K* lights a lamp at the repeater test jack (Figure 1), holds relay *H*, and connects the *Pick Up* lead to relay *F*. As shown in the operation chart in the lower left corner of Figure 10, about 0.6 second later a ground pulse on the *Pick Up* lead operates relay *F* which locks.

About 0.6 second later an *Interrupted Ground* pulse holds relay *K* and (via heavy dotted line) operates relay *G*. Relay *G* breaks the 110-volt collection circuit (heavy solid line). The inductive surge from the paystation coin-relay coils is absorbed largely by capacitor *A*, which protects relay *G* contacts. Relay *E* releases. Normally, the coin-relay armature restores, and disconnects the coin relay from the + line (Figure 3).

About 0.4 second later ground is removed from the *Interrupted Ground* lead, and relay *G* reconnects + 110 volts to the + line to test whether the coin relay has restored. The coin having been collected properly, relay *E* does not re-operate, and slow-release relays *K*, *H*, and *M* drop off one after another in that order. Relay *K* extinguishes the lamp. Relay *M* releases *F* and *P*, permits the interrupter to stop, and releases the linefinder. The equipment now is normal and ready for another call.

Full coin receptacle

At a pier just after a ship lands, or at a dormitory or barracks the day before a holiday, paystation traffic is heavy.

Perhaps the paystation coin receptacle has been filled to capacity by a prior call. The coin or coins

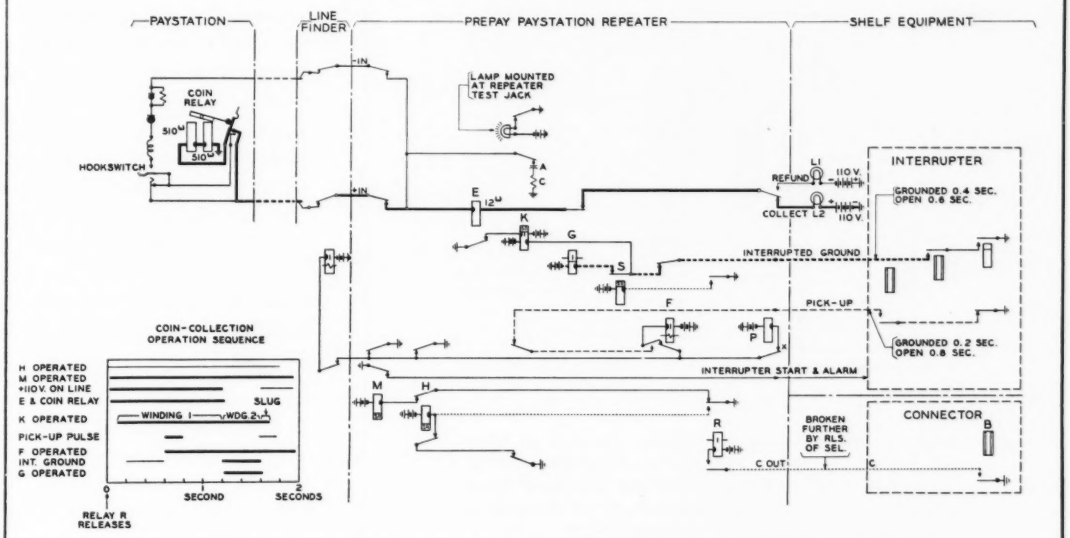


Figure 10. Collection procedure starts when connector removes ground from lead C *OUT*. Some 0.8 to 1.2 seconds later, i.e., just after the end of the pick-up pulse, conditions are as shown above.

just collected for our hypothetical call cannot fall into the coin receptacle; they back up into the hopper and may prevent the coin trap bottom from restoring. The coin vane, the "operating arm," and the coin-relay armature likewise cannot restore, so the coin-relay coils remain connected to the + line (Figure 11). Upon each release of repeater relay *G* (Figure 10), relay *E* re-operates, and holds *K* which keeps the lamp lighted and holds *H* and thereby *M*. Upon each re-energization of the coin relay its "operating arm" jostles the vane and the trap bottom somewhat, and may be able to shake the coin or coins down enough for the coin relay to restore. If it does not, prolonged operation of repeater relay *M* keeps the *Interrupter Start and Alarm* lead grounded too long, and the interrupter sounds an alarm.

The lighted repeater lamp identifies the call to be traced. A collector or serviceman is dispatched to the paystation to clear the jam.

Refunding

Like collection, refunding for a local call occurs after the calling customer has hung up. Refunding may take place in either of two ways.

One case, flash busy, has been suggested earlier (Figure 9). Referring to Figure 8, we find relays *R* and *H* operated, but relay *P* unoperated. Release in this case takes place almost exactly as discussed for Figure 10, with the exceptions only that relay *P* is unoperated, — 110 volts are applied to the + line, and the polarized coin relay tilts its armature in the direction opposite to that shown in Figure 11.

More common are the refunds due to a call being abandoned after deposit, a call to a busy number (busy tone without flash), a call to the telephone company business office or to the police or fire department, or an unanswered call. In these cases, repeater relay *S* has operated, but relays *R* (Figure 6) and *H* (Figure 10) have not. Therefore we cannot operate relay *M* as we did in Figure 10, but we have a method shown in Figure 12. When the caller hangs up, repeater relays *A* and *G* restore, and relay *C* operates. A moment later, repeater relay *B* restores (but operated relay *C* keeps lead *C IN* grounded to hold the linefinder) and opens the circuit of slow-release relay *S*. When relay *S* restores, it operates relay *M* and opens the circuit of slow-release relay *C*. Relay *M* operates,

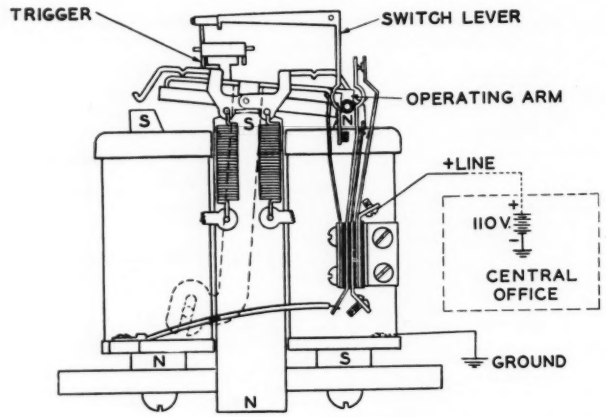


Figure 11. Coin relay making a collection. Although the switch lever has been reset to normal, the operating arm keeps the magnet coils connected to the + line until coin-control current is removed. For refunds, the armature tilts in the direction opposite to that shown.

holds the linefinder, and, relay *P* being unoperated, connects — 110 volts to the + line (Figure 10 heavy line) thereby operating the coin relay and relay *E*. Relay *E* operates relay *K* which holds relay *M* (Figure 12) until refund has been completed. In other respects, refund coin control is completed as in Figure 10.

CLR calls

On calls to long distance and to special-service numbers, early paystation repeaters repeated pulses for the first digit without coin deposit. Needless to say, this complicated the circuits not only of the paystation repeaters but also of the selectors. There is so little demand for this feature that it has not been included in the present standard paystation repeater (Figure 1, right).

To call long distance, the calling customer deposits at least the charge for a local call, and then he dials. When the operator answers, the CLR trunk circuit reverses battery to the paystation repeater, which switches through as in Figure 8, connecting the caller directly (except for repeater relay *J*) to the CLR trunk circuit. The CLR trunk circuit itself then applies — 110 volts to the two sides of the line for a moment to refund the deposit and, thereafter, switches the calling line (through repeater relay *J*) to the trunk jack. Then the operator and the paystation customer converse. After about 8½ seconds pay-

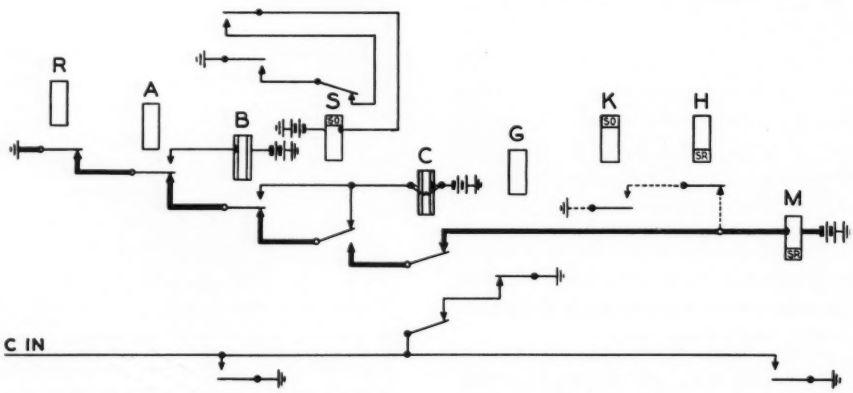


Figure 12. Method to operate relay M for a refund after an abandoned call, busy (tone busy), don't-answer, intercepted call, call to a free-service number, etc. Repeater relays A and B have just released. Relay S is about to release and will operate relay M.

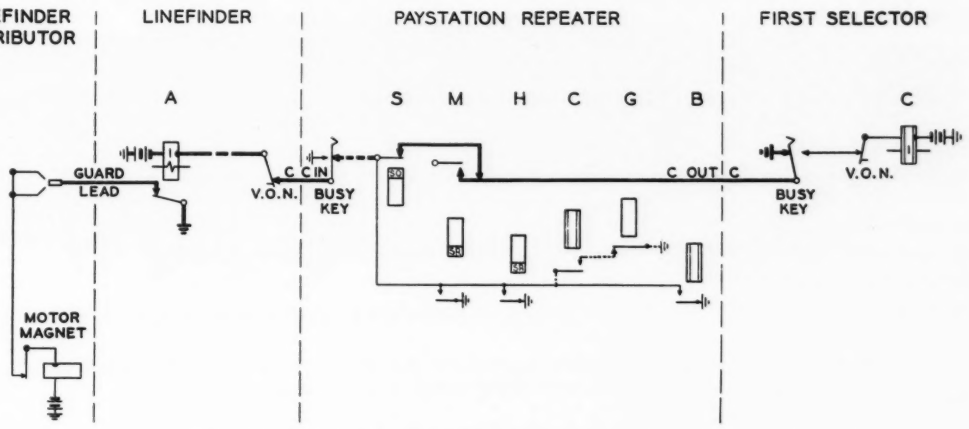


Figure 13. Control lead C of the linefinder-repeater-selector link. In the normal condition, C *OUT* is connected to C *IN*; therefore, operation of first-selector busy key would take linefinder out of service as shown by heavy line. Diagram shows also how, after coin deposit, relay *S* splits C *IN* from C *OUT* (relay *B* holds linefinder until called party answers, after which relay *H* holds linefinder). During coin collections and refunds, relay *M* both keeps C *IN* split from C *OUT* and holds linefinder.

station repeater relay *P* operates and locks (Figure 8).

There are numerous reasons for reversing battery to paystation-repeater relay *R* and for having the paystation repeater switch through when the CLR operator answers. The switch-through:

1. Removes the repeater equipment (except relay *J*) from the talking circuit to minimize attenuation and to permit toll-grade transmission battery from the toll board to reach the paystation.

2. Clears a through circuit for the automatic refund pulse which the CLR trunk circuit sends to the paystation coin relay as soon as the operator answers.

3. Places the repeater (and, through it, the linefinder) under control of lead *C OUT*, which is held by the toll switchboard. Without danger of releasing the connection, the calling customer can manipulate his hookswitch slowly to recall or "flash" the CLR operator for further instructions or information.

4. Clears a through circuit for the CLR operator to collect or refund the deposit advanced for the toll charges.

5. Sets the paystation repeater for collection so that if the toll operator, forgetting this is a call from a paystation, neglects to collect the deposit, when she takes down the connection the paystation repeater goes through the operations of Figure 10 and collects.

Tolls for long-distance messages (both CLR and "delayed") are collected or deposits refunded by the toll operator (see item 4, above) and are controlled from the toll-switchboard position circuit. The paystation repeater performs no active function on toll calls (except occasionally item 5 above).

Calls to the paystation

On a call *to* a paystation, the paystation repeater is not part of the switch train; the call is completed by a connector in the usual way. The coin relay is normal (Figure 3) and disconnected throughout the incoming call; the paystation telephone circuit is just like that of any other telephone. This is true both for local and for long-distance incoming calls.

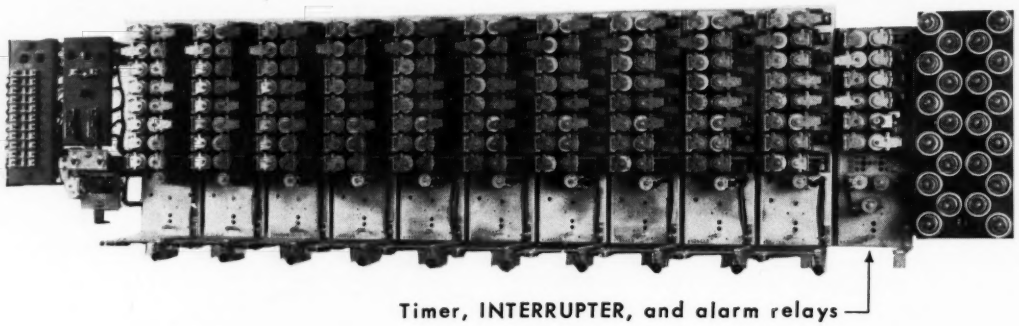


Figure 14. Shelf of ten prepay paystation repeaters with their timer, interrupter, and alarm relays, and 110-volt current-limiting protective resistor-lamps.

Inward "collect" toll calls

It is desirable to assign to paystations directory numbers beginning with *9*. A distant intertoll operator who has a reverse-charges call to a telephone whose number begins with *9* does not dial the terminal number but routes the call through an inward operator who has a special directory from which she determines whether the call is to a paystation and cannot merely be ticketed. The paystation repeater is not part of the switch train. Collection is controlled from the inward toll-switchboard position circuit.

Busying

Maintenance switchmen are acquainted with the fact that if a first selector is to be inspected and is to be taken out of service, operation of the first-selector busy key takes also the associated linefinder out of service. This fact holds even when the prepay paystation repeater is inserted between the linefinder and the first selector, as shown by Figure 13 heavy line. Also, operation of the repeater busy key would take the linefinder out of service.

Physical Arrangements

Common equipment

Figure 14 shows a shelf of ten prepay paystation repeaters at the right of which are the timer, interrupter, and alarm relays. The timer, interrupter, and alarm relays are rated to serve up to thirty repeaters: the ten repeaters on their own shelf plus the repeaters on two other shelves. Usually, one timer, interrupter, and alarm relays group suffices for a 10,000-line central office.

At the extreme right-hand end of the shelf are twenty-two resistor-lamps. Twenty of these are the lamps *L1* and *L2* of Figures 8 and 10, one of each for the ten repeaters on the shelf. In addition, the timer, interrupter, and alarm relays group has one refund-voltage lamp and one collect-voltage lamp, used for voltage-failure alarms.

Coin-control power source

In the early days of prepayment service, dry cells, or occasionally even small-capacity storage batteries, provided the + 110 and the — 110 volts required for prepayment coin control. Dry-cell batteries still are used in some installations.

It is more usual, however, to get these voltages from d-c dynamos added to the shaft of a rotary ringing machine.

Selenium-rectifier units have been developed recently for prepay paystation coin control. As these operate from commercial a-c power, if a rectifier unit is used, it is advisable to have dry cells (perhaps "B" batteries) available to be cut in if the a-c power fails.

THE AUTOMATIC PRIVATE TELEPHONE SYSTEM OF THE BELGIAN NATIONAL RAILWAYS

By R. F. STEHLIK

SYNOPSIS: ***Switching arrangements—principal, secondary, and tertiary exchanges—party lines—trunking and methods of connection—interurban calls—ringing and tone supplies—alarms.***

IN 1945, immediately after the war, the Belgian National Railways (Société Nationale des Chemins de Fer Belges) decided to accelerate the modernisation of its private telephone network as a fundamental part of the vast programme for the reconstruction and electrification of the railway system of Belgium, and a contract for the realisation of the greatest part of the automatic teleswitching programme was entrusted to Automatique Electrique, S.A. ("A.T.E.A."), Antwerp. At the time this was written, the Antwerp and Ghent centers and the major part of the centre of Brussels were equipped by Automatique Electrique, S. A. These centres are in full switching interconnection also with existing exchanges of other types in Brussels and other places. The remainder of the work will be carried out in progressive stages.

The switching requirements for a railway network differ in a number of respects from those of a purely local automatic exchange area; consequently the circuit designers were presented with many unusual and difficult problems of circuit design. Because of its versatility and adaptability, Strowger switching technique has been followed in the design of the system; and in the following description some indication is given of how the requirements of the system have been met.

Switching Arrangements

Principal and Secondary Exchanges

The magnitude of the project and the extent of the communications network ultimately to be provided will be seen from Figure 1 which also shows the numbering scheme.

For switching purposes the country is divided into ten zones, each zone having a principal exchange with as many as 9 associated secondary exchanges. Some of the principal exchanges are interconnected with satellite exchanges which share the numbering scheme of the principal or parent exchange through which the satellite main traffic is routed. Brussels principal centre is also directly connected with all principal exchanges, as shown in Figure 2, and thus becomes the main transit or interconnecting centre. Direct junction circuits are also provided between a number of the principal exchanges. These circuits are first choice routes for traffic between the exchanges so connected and also carry overflow traffic. For example, if the direct circuits between Mons and Brussels are all busy, traffic is automatically routed via Charleroi.

The facilities available at each principal and secondary exchange permit (a) local dialling within its area and (b) dialling to any other principal or secondary exchange; i.e. interurban working. On interurban calls a three digit prefix is used; the first digit is 9, the second digit indicates the zone, and the third digit selects the zone exchange. Provision is made for interconnection between the principal exchanges and the public telephone system. Outgoing calls are dialled. Incoming calls reach an operator who, at a cordless switchboard, sets up the call to the required subscriber. Trunk holding and information facilities are provided.

Tertiary Exchanges

These are exchanges which provide service for small groups of 10 or 20 subscribers. The exchanges are interconnected with principal or secondary exchanges as shown in Figure 3.

Figure 1. Showing principal and secondary exchanges and their numbering scheme in the communications network which is divided into ten zones.

Party Lines

An essential requirement of a railway telecommunications network is the availability of telephone service between the less important stations on lines running between two points. Usually a party line having up to 24 telephones connected on one circuit provides the service. In the Belgian network both omnibus working, using code calling, and a fully automatic system are provided for the most important lines. For the latter a fully selective and secret system has been designed and developed by ATEA and provides the following facilities:

1. Dialling between any two stations on the party line.
2. Group calling of all stations.
3. Interconnection with any telephone station in the entire railway network.
4. Full secrecy.
5. Emergency intervention.

Dividing the line into sections by means of impulse repeaters makes possible the busying only of the section or sections engaged in conversation, the remaining sections being left free for other calls.

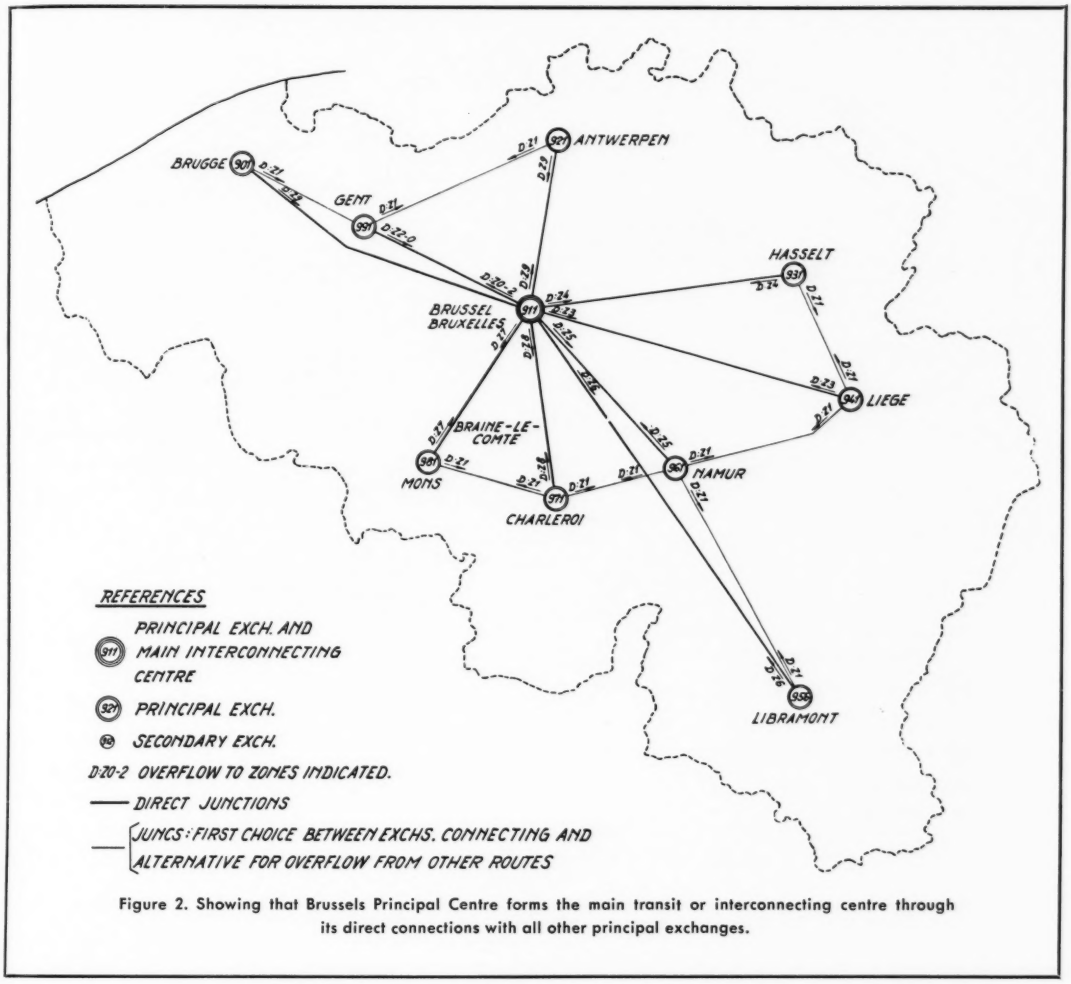


Figure 2. Showing that Brussels Principal Centre forms the main transit or interconnecting centre through its direct connections with all other principal exchanges.

The complete party line network is shown in Figures 4 from which some idea of the extent of the railway system can also be obtained. Figure 12 is a photograph showing a selective party line unit comprising telephone, relay set, rectifier and 6-volt secondary cell battery.

A feature of the whole switching system is the use of an identifying dial tone at principal and secondary exchanges. The tone is interrupted to form Morse code signals, the receipt of which enables a caller to verify that the correct exchange has been reached. The design of switch outlet circuits is based upon the use of battery testing during search, thus ensuring maximum immunity from failure due to faulty outlets.

Trunking and Method of Connection

Principal Exchange

The trunking scheme is shown in Figure 5. Subscribers' calling equipment includes 12-point non-homing uniselectors, the circuit of which is so designed that upon replacement of the telephone handset at the end of a call, the switch wipers move forward one step to ensure that on succeeding calls a different outlet is used.

Preselector bank terminals are provided so that special conditions may be imposed by means of

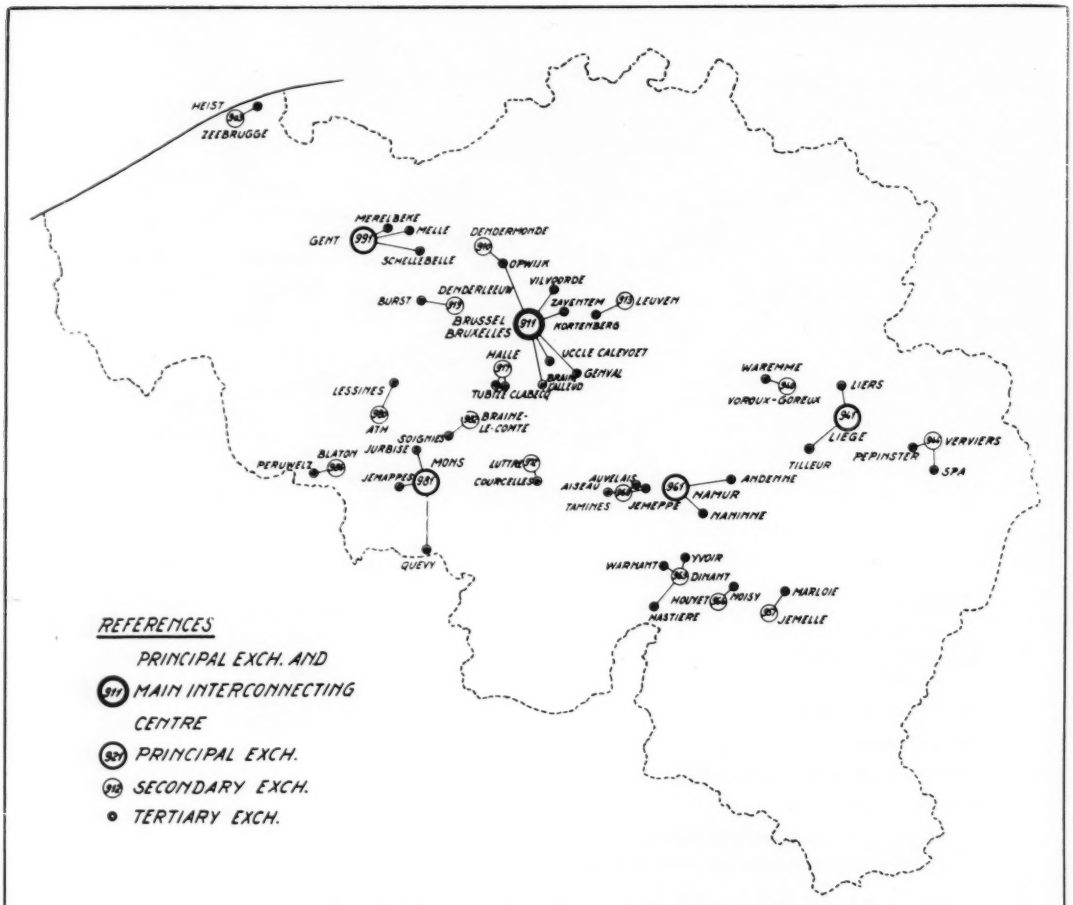


Figure 3. Tertiary exchanges, showing their interconnection with principal or secondary exchanges.

wire strappings. The special conditions include "overriding of busy" to provide priority or "cut-in" service, and "restricted access" to the public exchange system, for incoming calls or outgoing calls or both.

Level 7 is used for routing calls to omnibus and selective party lines. The number of such lines is usually restricted to ten on any exchange. Procedure for calling party lines is as follows: Dialling the digit 7 routes the call to a 10-point selector, to the bank of which both omnibus and selective party lines are connected; the individual party line digit is then dialled to reach the required circuit. A series of digits, to signal the called party are now dialled—digit 2 for a short ring and digit 7 for a long ring, causing the code of the called station to be sent out. Release of the connection is under the control of the automatic subscriber.

Calls originated by an omnibus party line subscriber are set up by the caller ringing a code-discriminator associated with a relay repeater terminating the line; this causes a signal to be given to a manual operator who sets up the call to the required line.

Calls to a selective party line are fully automatic; the stations have regular directory numbers and may originate and receive calls like a

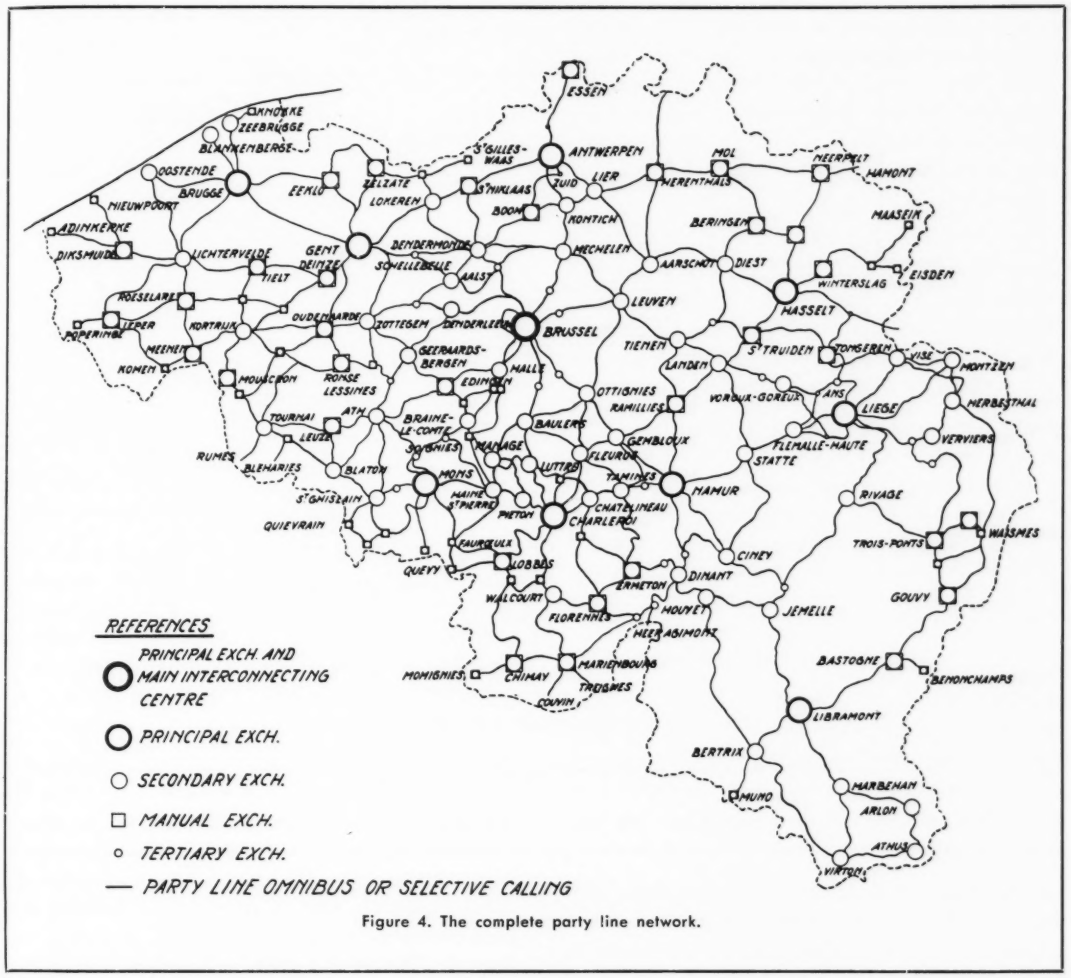


Figure 4. The complete party line network.

normal automatic subscriber.

Release occurs when either party replaces the handset; if a handset is not replaced the telephone is disconnected but is left in a condition to receive calls, in which case the handset must be replaced and then removed to answer.

If a selective party line subscriber removes the handset but does not promptly proceed to call, the offending telephone is disconnected from the party line by forced release after 30 seconds, but as in the previous case, is left open for receiving calls.

Each party line telephone is provided with a push button, normally sealed, which is used if and when it becomes necessary to intercept a conversation in case of an emergency call.

Interurban calls

Level 9 is used for routing interurban calls. The level is connected to interurban second selectors which are extended to 2-digit registers via preselectors. As already stated, a 3-digit prefix is dialled on interurban calls.

In order that the second code digit (*B* digit) shall not be mutilated or lost while the preselector is searching for and connecting to a register, the digit is dialled on the interurban selector; the third code digit (*C* digit) is dialled into the register.

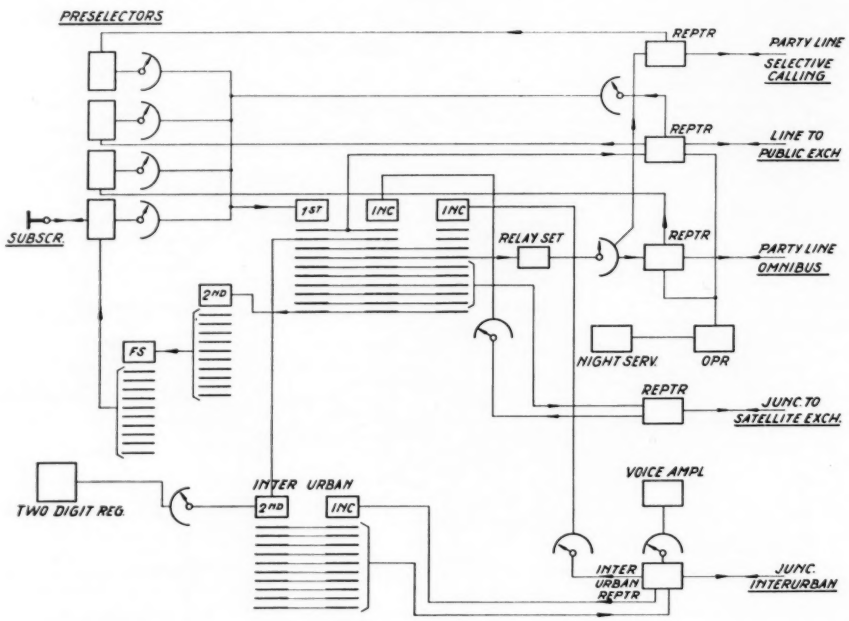


Figure 5. The trunking scheme of principal exchanges.

The *B* digit indication is then passed into the register over an auxiliary circuit.

Interurban junctions may be of two types, carrier and inductive. The interurban relay repeater is designed to handle either type and has access to a voice repeater which permits the switching in of a speech amplifier if necessary, dependent upon the class and length of the lines to be interconnected.

Referring again to Figure 5 and Figure 2, let it be assumed that a subscriber on Mons exchange calls a subscriber on Antwerp exchange. Digit *9* is dialled, extending the call to an interurban 2nd selector; the *B* digit *2* and *C* digit *1* are then dialled. When the *B* digit has been received in the register, the interurban second selector is released and then re-dialled from the register, routing the call over level 1 to Brussels. The Mons exchange register transmits the *B* and *C* digits to the incoming (transit) selector at Brussels where they are received by a selector. The *B* digit *2* corresponds to the number of the level to which Antwerp junctions are connected, hence the wipers rotate on level 2 and seize a junction to Antwerp. The *C* digit is sent to Antwerp to indicate the destination prefix to the Antwerp incoming selector. The holding time of the register is consequently of very short duration as it is in use only during the receipt and retransmission of the *B* and *C* digits.

The caller at Mons will now receive the Antwerp identifying dial tone in Morse code, in this case the letter *A*, and will proceed to dial the required subscriber's directory number.

If the call had been intended for a secondary exchange in the Antwerp zone, the incoming selector at Antwerp would route the call over the appropriate level to the required exchange.

Release of a call is under the control of either subscriber (first party release). The last subscriber of the two to replace the handset will receive the

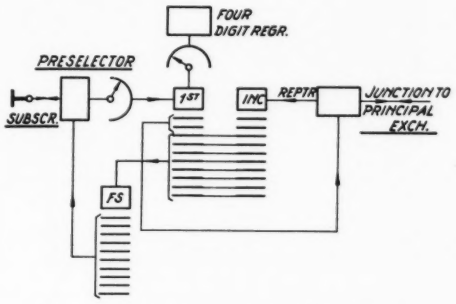


Figure 6. Trunking for a typical satellite exchange.

dial tone of his own exchange, thus receiving an indication that the other party is off the line.

Level 0 is used for routing calls to the public exchange system. On this class of call a subscriber may hold a public exchange call while making an information call over the railway network. An operator may also be signalled to transfer a call to any other authorized (non-restricted) subscriber on the exchange.

Incoming calls to a subscriber are set up via a cordless-type attendant's cabinet. Night service facilities are provided at a specially designated telephone on which incoming calls from the public exchange and from omnibus party lines can be answered and transferred to required subscribers. The night service telephone, however, is not provided with facilities for the camping on of trunk calls or call offering which are regular features of the cordless position.

Public exchange calls are restricted to a particular principal or secondary exchange and its satellites. Public exchange calls extended to satellite exchanges may be restricted in the same manner as calls within the principal exchange.

If an operator attempts to connect an incoming call to a restricted line in either the principal or satellite exchange, busy tone is received. If there is any doubt whether the busy tone is due to legitimate engaged conditions or to restricted conditions, the operator can override the busy and listen in on that line.

Secondary Exchanges

The trunking scheme for a secondary exchange of 60-line capacity is illustrated in Figure 7. In this case the first and final selector functions have been combined. Routing and switching are similar to

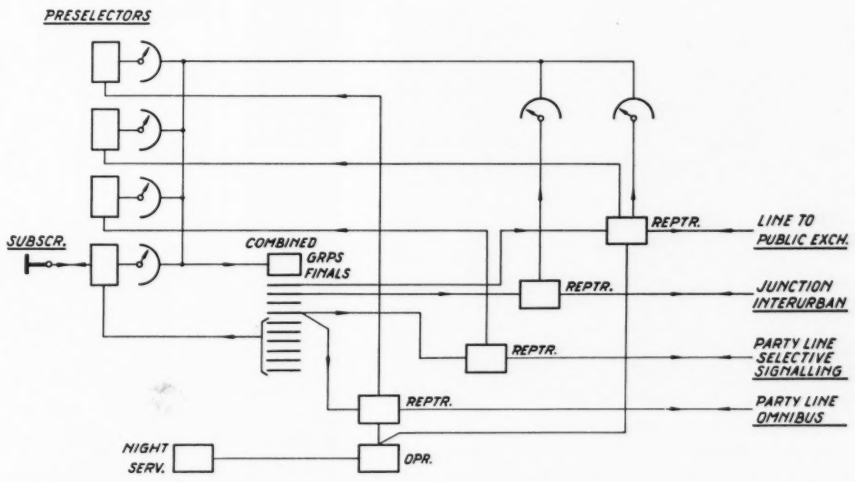


Figure 7. Trunking scheme for a 60-line capacity secondary exchange.

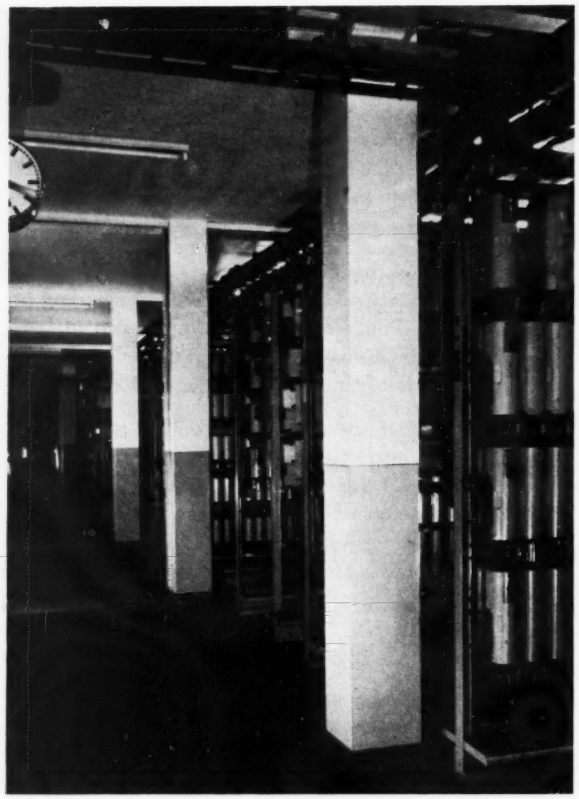


Figure 8. Partial view of Brussels Main Exchange.

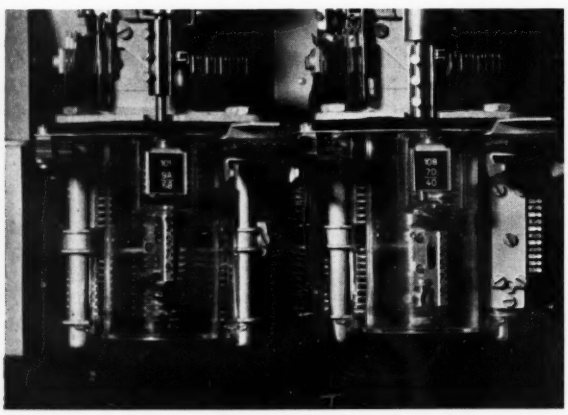


Figure 9. Transparent plastic front bank cover used for particularly dusty locations. An indicator is fitted to the switch shaft which in combination with moulded numbers on the plastic cover facilitates reading the position of the wipers in operated position. Two types of covers are shown; on the left for switches with a vertical bank, on the right for those without vertical bank.

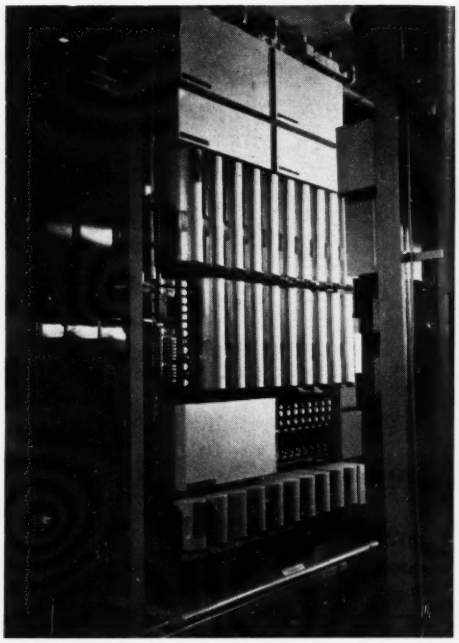


Figure 10. Public exchange repeaters for combined incoming and outgoing, outgoing only, and information pre-selectors.

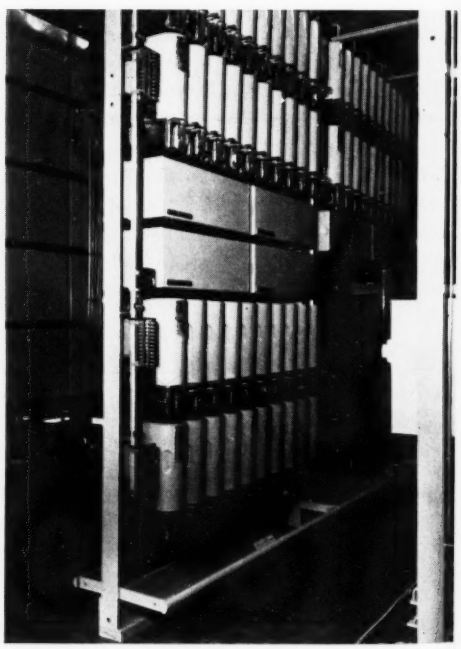


Figure 11. Rack of discriminating selector repeaters and associated pre-selectors.

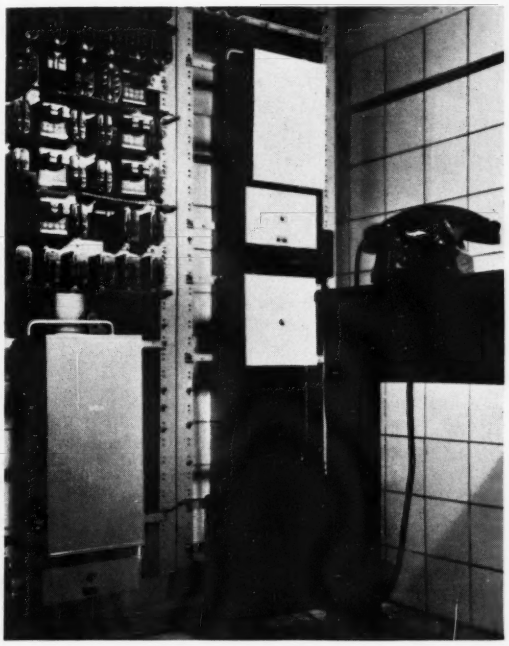


Figure 12. The selective party line installation shown on the right hand side of rack consists of the relay unit with its terminal block and repeating coil unit—the two top covers. The third cover protects the rectifier unit. The 6-volt storage battery is mounted near the floor. The telephone set proper is visible on the table. The same picture shows a sectioning repeater which is mounted on the bottom of the adjoining rack.

those described for principal exchanges, with the exception that registers are not provided on the interurban circuits. Dialling digit *9* selects a free circuit to the principal exchange where an interurban second selector and register are taken into service to handle the call.

Interurban calls incoming to a secondary exchange reach a final selector through an interurban repeater via a preselector.

Satellite Exchanges

Figure 6 is a sketch of the trunking for a typical satellite exchange. As these exchanges are smaller than principal exchanges and require fewer digits, some measure of translation is necessary; hence a 4-digit register is used. It is also necessary to provide a controlled interdigital pause on calls to a principal exchange when several free-hunting operations follow each other. This is provided by the register.

Calls to the principal exchange are routed over levels 9 and 0. Level 0 is used to reach the public exchange circuits at the principal exchange, preselector bank strappings being used for lines restricted from access to the public exchange network.

Calls from a satellite exchange to the principal exchange and to the remainder of the railway network are routed over level 9. This level shares repeaters with level 0.

Dialling over interurban junction circuits, other than carrier circuits, is effected by use of inductive current pulses which pass over the line and are received on polarised relays of the telegraph type. This method of pulsing out permits the use of long junctions requiring a number of pulse repetitions, without causing signal distortion.

Ringing and Tone Supplies

These are derived from the usual type of dynamotor, fitted with additional cams and spring sets

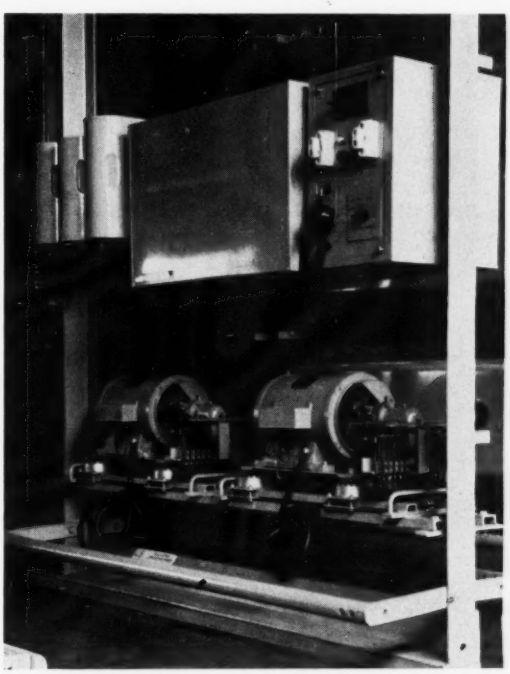


Figure 13. Twin ringing machine shelf with supplementary shelf of control and test equipment.

to provide the Morse code interruptions mentioned. In the larger exchanges the machines are in duplicate, with automatic change-over from the machine in service in the event of a failure of any type.

Alarms

These are both visual and audible. Visual alarms are repeated on a floor, aisle, rack, shelf and individual switch or apparatus unit basis, thus enabling an attendant to be directed quickly to a trouble spot. When an exchange is unattended, its alarm circuits are extended to the parent exchange, urgent and non-urgent alarm signals being transmitted separately.

Conclusion

Sudden and unforeseen changes in railway traffic, resulting in additions to or withdrawals from service, accidents or other emergencies, call for a telecommunications service in which the paramount requirements are the rapid establishment of connections and immunity from failure. For the Belgian Railways these requirements have been met by using Strowger equipment and well-designed circuits, providing straightforward selection and operation and simplicity of maintenance without the need for elaborate and complicated testing and observation devices.

(This article is published with the kind permission of Société Nationale des Chemins de Fer Belges. In making this acknowledgement Automatique Electrique, S. A. pay tribute to the administrative and technical direction of S.N.C.F.B. by whose enterprise and vision Belgium will be served by a railway system the world may use as a model.)

SIDELIGHTS ON THE DEVELOPMENT OF THE STROWGER AUTOMATIC DIRECTOR

(Continued from page 78)

structed entirely of the types of mechanisms that are used in conventional Strowger systems, including relays; the Strowger up-and-around mechanism, with its shaft, wipers and banks; and single-motion stepping switches, both "minor" and "rotary". All of these switching mechanisms have been part of the Strowger system for years, and their operation is understood by telephone engineers and maintenance men in all parts of the world. Thus, when the Director is introduced into an exchange already having Strowger automatic equipment, the process consists of merely adding more of the same variety of apparatus with which the operating and maintenance personnel are already familiar.

It was the recognition of this sound principle by the British Post Office in the early 20's which played a major part in the decision to adopt the Director for the large city networks in Great Britain. It enabled the staff, both engineers and maintenance personnel, who were already familiar with Strowger equipment and its operation, to carry on in the larger cities without the need for being educated in the intricacies of another system. Another important factor that the British Post Office recognized was that the Director could be introduced into any Strowger exchange when it expands to a size where Director features would be required, without the need for making fundamental changes in the existing equipment. From the economic point of view the Director can, as a rule, be introduced at any time that the extra cost of providing individual groups of incoming and outgoing trunk cables between an office to be added to the network and all of the presently existing offices equals or exceeds the cost of the Directors.

The development of this ingenious straightforward switching unit, which is constructed of standard Strowger relays and switching mechanisms, and which can be introduced into an existing system without major alterations is indeed a tribute to the Strowger engineering and laboratory staff.

STROWGER AUTOMATIC SWITCHING FROM REVERTIVE PULSE SOURCES

By W. J. PHILLIPS

SYNOPSIS: ***Requirements of revertive pulse switching — the Converter — physical design—the conversion of a call — special signals — traffic and trunking.***

PANEL and Crossbar automatic systems are used by operating companies of the Bell System in some of the larger metropolitan areas in the United States. To establish station-to-station intra-office or inter-office connections, these systems use revertive pulsing. This method of pulsing is entirely different from the direct dial control pulsing used in most Strowger Automatic (step-by-step) systems and cannot be used to control step-by-step equipment directly. Thus special conversion apparatus must be utilized if and when an operating company desires to extend subscriber-dialed calls from an office using revertive pulsing to subscriber stations in a step-by-step office.

To meet the need for such special conversion equipment, Automatic Electric Laboratories have designed apparatus for use in Strowger offices which permits calls from Panel or Crossbar offices to be extended to, and completed in, step-by-step offices by means of the same revertive pulse trains which are transmitted when the called station is located in another Panel or Crossbar office. Thus no restrictive or special arrangements are required in Panel or Crossbar offices when subscribers therein dial calls which terminate in Strowger step-by-step automatic offices.

This article describes the Strowger Converter which was designed to convert revertive pulse trains to their step-by-step equivalents.

Requirements of Revertive Pulse Switching

Under the revertive pulsing method, digits dialed by the subscribers are stored in senders, which in turn control the operation of the selectors by means of revertive pulses. The digits dialed (assuming 7-digit numbers) are stored on seven sets of pulse-storing relays. As soon as the office code (first three digits) has been received, the sender requests routing information from a "decoder" and connects itself to a district selector. This unit transmits revertive pulses to the sender, which in turn controls selection of a required trunk group. When an idle trunk has been found in the selected group, control of succeeding switching stages is extended on the same basis. That is, the sender does not actually "send" any pulses, but controls the switching operation of the various panel selectors by counting revertive pulses received when the selector is seized.

Inter-office subscriber calls require the transmission of five groups of selection pulses to reach a four-digit terminal number in a called office. These selections are called *Incoming Brush (IB)*, *Incoming Group (IG)*, and *Final Brush (FB)*, and are received in that order. The tens and units digits are transmitted as *Final Tens (FT)* and *Final Units (FU)* and make the fourth and fifth selections. For example, the *IB* relays determine to which 2,000 lines in a 10,000-line office the call is being placed. The *IG* relays determine to which 500 lines in the 2,000-line group the call is going, and if the trunk serves two 10,000-line units, to which unit of the two. The *FB* relays determine the 100-lines in the 500-line group to which the call is being sent. The *FT* and *FU* relays determine the called line in the 100-line group. In this manner one of 10,000 or 20,000 terminals may be chosen by receiving five revertive pulse selections.

The apparently long holding time for the above five selections is offset by a fast inter-office impulse speed which is approximately 25 pps. Thus the time required to transmit selections for a call to the highest possible number (9999) in an office is about two seconds.

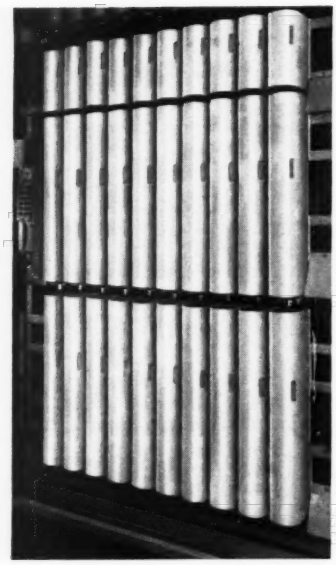


Figure 1. (Left) Group of ten Converters shown mounted on frame.

Figure 2. (Right) Transmission unit of the Converter with cover removed.

Requirements of Strowger Automatic Switching

Middle States Telephone Company of Illinois, which operates offices at Park Ridge and Des Plaines (two suburbs immediately northwest of Chicago) decided several years ago to install Strowger Automatic switching equipment totaling approximately 16,000 terminals. In the planning and engineering of this conversion, Automatic Electric Company made every effort to furnish equipment of the latest design. Directors and Strowger Automatic Toll Ticketing (SATT) equipment were provided so that Park Ridge and Des Plaines subscribers could obtain connections with subscribers in the Chicago Metropolitan Area on a direct, subscriber-dialed, automatic-ticketed basis. The fact that these calls would terminate in Crossbar or Panel offices did not present any pulsing problems, because these systems are so arranged that they can accept and be controlled by pulses which have a speed of 10 pps. For intra-office calls and inter-office calls between Park Ridge and Des Plaines, regular Strowger step-by-step operation was provided.

Incoming calls from Panel and Crossbar offices, however, presented a problem because these systems extend and establish connections by means of revertive pulsing as indicated in the foregoing. The problem, then, was how to control Strowger switching equipment on incoming calls from revertive-pulse offices.

The Converter As a Solution

When the Park Ridge and Des Plaines offices were cut over to automatic operation on May 27, 1950, the Converter (see Figures 1 and 2), a new unit which had been developed by the Automatic Electric Laboratories, was included in the switching equipment. These Converters were designed to provide positioning control at Strowger step-by-step switches from revertive pulses sent out from Chicago-area Crossbar and Panel offices. Converters are used as common equipment in an office, and are used only for the time necessary to establish a connection. Each incoming trunk from Crossbar and Panel offices is terminated on a trunk repeater and on an AB toll fourth selector. A rotary switch, termed a "Converter hunter", is associated with each repeater. Each trunk repeater has access, by means of its Converter hunter, to a maximum of 24 Converters. Should there be fewer than this number, switch-hunting time may be reduced by providing multiple appearances of Converters on the Converter-hunter bank.

Physical Design of the Converter

The Converter consists of twin-contact relays, single motion rotary switches, and a constant speed d-c motor-driven 10 pps. pulse generator. These components are mounted on three jacked-in bases, one above the other, and are wired so that all three units function as one complete Converter. Generally speaking, the upper base controls and generates revertive pulses, and the lower base registers the revertive pulse selections. The center unit (see Figure 2) controls the other two units and also controls the transmission of a translated terminal number to the Strowger equipment.

Conversion of a Call

Seizing the Converter

A call originating in a Crossbar or Panel office and destined for a Park Ridge or Des Plaines sub-

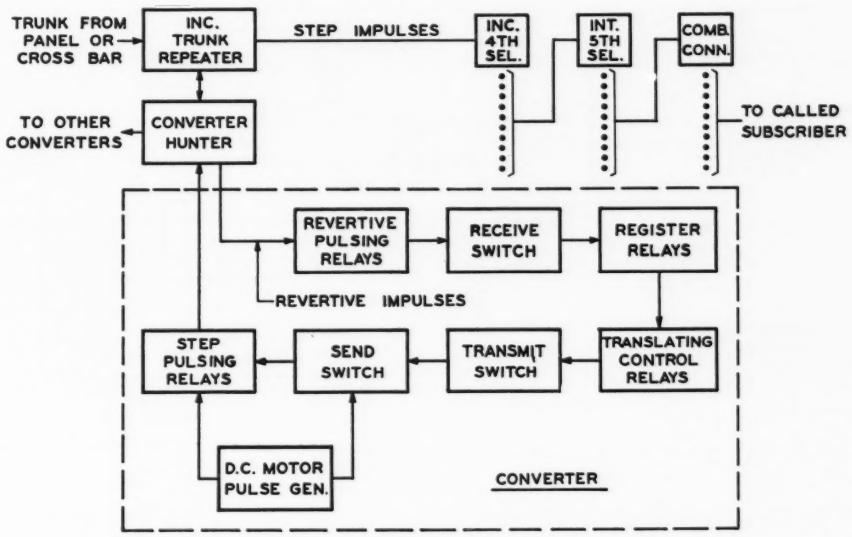


Figure 3. Block diagram of the Converter.

scriber will be extended to a sender in the originating office. As soon as the called office code has been dialed, the sender and its associated translator will select an idle inter-office trunk to the called office.

After the first two terminal digits have been dialed, the originating sender will test the trunk for polarity and potential, and, if satisfied, will cause the terminating trunk repeater, via its associated Converter-hunter, immediately to search for and seize an idle Converter and to connect the trunk through to the Converter, whereupon revertive pulsing can start. Figure 3 shows a block diagram of a Converter.

The originating sender is able to recognize the trunk repeater *A* relay (initial seizure relay) and the transfer to the Converter connection by the trunk current flow on these two conditions. That is, because of the different values of resistance in the seizure circuits on incoming trunk and Converter connections, the trunk flow will tell the originating center exactly when a trunk repeater or converter is seized.

Supplying the Revertive Pulses

Revertive pulses on the trunk from the Converter to the originating sender are generated and controlled by relay equipment very similar to that used in Crossbar terminating senders. This relay equipment is adjusted to supply revertive pulses of the character required by the originating senders. Pulsing is on a self-cycling shunt-down basis, and is arranged to include the trunk loop and originating sender in the circuit.

The basic revertive-pulse circuit is shown in Figure 4. When the Converter has been seized and has thus been made ready to accept information, the trunk from the originating sender has ground on one side, through relay *STP (B)*, and battery on the other (through relay *L*). Revertive pulsing consists of alternately closing and opening a direct ground to the "battery" side of the trunk. Relay *GR* performs this pulsing function as it cycles with relay *STP (B)*. That is, once relays *L, L1, L2,* and *STP (A)* are operated, relays *STP (B)* and *GR* will cycle until the trunk loop is opened at the originating office. Relay *STP (A)* counts the *GR* relay pulses at the originating end; pulsing of relay *GR* also steps a "receive" rotary switch (Figure 5) at the receiving office to initiate the registering of revertive pulse selections in the Converter. Thus

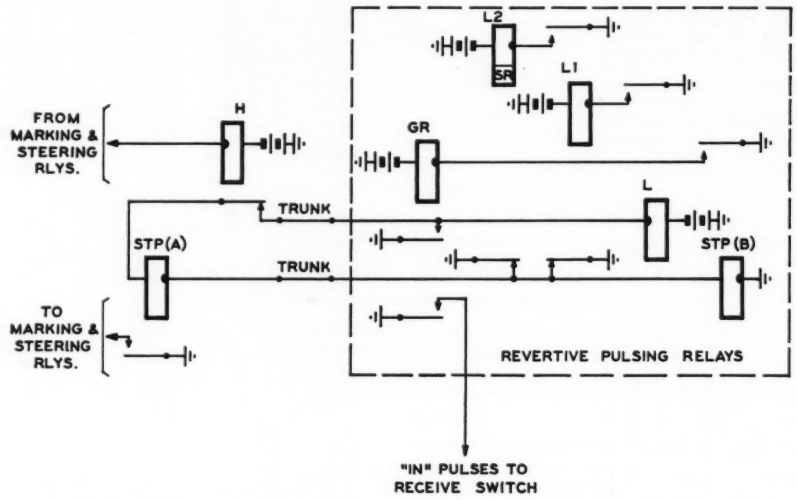


Figure 4. Simplified diagram of the five relays in the Converter which supply revertive pulses back to the originating sender.

the Converter pulses both out to the originating sender and into its register relays in order to receive and register information stored in the originating sender.

Pulsing of the trunk and mutual counting continues until the originating sender has counted to the mark indicated in its marking and steering relay group. When this mark is reached, the originating sender immediately opens the trunk loop by operating relay *H* (Figure 4), holds it open for 200 ms., and then closes it.

The 200 ms. open period causes all five of the impulse generating relays to release, and indicates to the Converter that the relay selected by the present position of the receive rotary switch is to be operated for the incoming brush selection. One of the *IB* relays then operates and locks for the duration of the converter use on the call, causing the Converter to reset itself to receive the next digit.

The Converter is arranged so that once a mark is indicated the marking cycle interlocks all units involved, and pulsing will not begin again until the Converter is clear to receive the next selection.

The incoming group, final brush, final tens, and final units selections are received in the same manner as described above, with the same inter-selection control. However, if the Converter is ready to pulse a selection which has not yet been dialed into the originating sender, the trunk is held open at the originating end until the digit is dialed, and until that time all five pulse relays remain normal. Therefore, since the trunk can be held open for several seconds or more between selections, the trunk repeater is designed to lock on seizure to a timed-out release, in case dialing is never completed. Complete dialing will release the Converter regardless of timing.

Stepping the "Receive" Switch

Figure 5 depicts in simplified form the method used to drive the receive switch from pulses of the *GR* relay (Figure 4). With the circuit at normal and the locking ground supplied, a ground pulse closed to the "in" lead will operate relay *A*. Opening of the in-pulse circuit removes the short circuit from relay *C* and allows it to operate in series with *A* to the locking ground. Relay *A* then holds in an operated position. The receive switch takes one self-interrupted step when relay *C* operates.

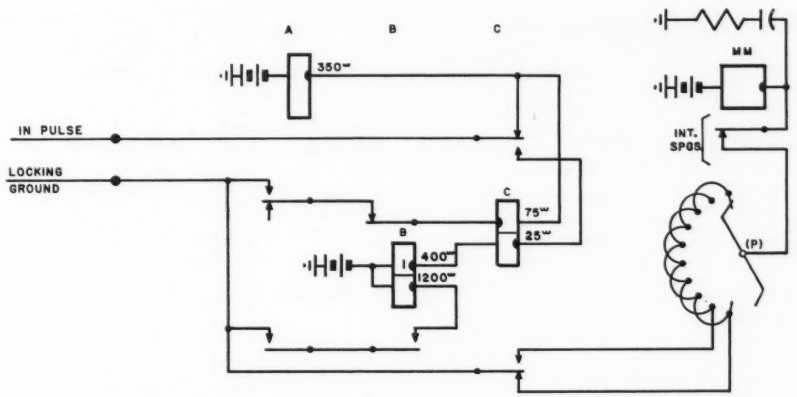


Figure 5. Simplified diagram of the "receive" rotary switch in the Converter.

The next in-lead ground pulse closure will operate relay *B* in series with the second winding of relay *C*. Relay *B* locks through contacts of relay *A*, and at the same time opens relay *A*. Relay *A* then restores. Removal of the in-lead ground pulse releases relays *B* and *C*. The receive switch takes one self-interrupted step when relay *C* restores. This cycling will continue as long as the locking ground and in-lead ground pulses are maintained, causing the receive switch to advance one step for each operation or release of relay *C*.

Sending

After the first three selections have been registered, the Converter has received enough information to start sending step-by-step pulses back through the trunk repeater to the incoming toll fourth selector and succeeding switches to set up the thousands and hundreds digits. Therefore, sending starts and continues at the same time the Converter is pulsing in the tens and units selections. This overlap of functions is normal in most register-sender devices and reduces the holding time of the Converter.

As soon as all five revertive selections have been received, regardless of the step-by-step sending status, the Converter clears and releases the originating sender. This is done by a momentary reversal of the trunk polarity back to the sender.

A reversed trunk back to a sender any time after trunk seizure will clear that sender from a call. In addition, the Converter during its normal release cycle will remove all potentials and charges from the trunk so that when the calling subscriber is switched through there will be a noise-free connection.

Step-by-step sending will continue until all four terminal digits have been transmitted. At this point the Converter has completed its work and is ready to release from the connection. The trunk repeater releases the Converter at a signal from the Converter itself; the connection to the called party then remains extended from the trunk, through the repeater, fourth and fifth selectors, and the connector. The Converter is now immediately available for use by other trunk repeaters.

Since the method of pulsing into the Strowger switch train is similar to the transmitting scheme of the Director, it will not be discussed here in much detail. Revertive selections found on the first three groups of register relays are translated to codel marking—thousands and hundreds digits in WXYZ (codel) form—by means of translating relay contact chains (the tens and units selections are already registered in WXYZ form). Thus the relays on which the five received digits are stored mark the bank of the rotary transmitting switch in the WXYZ (codel) pattern. A send switch controls the sending of the four digits required to extend the call to the called terminal.

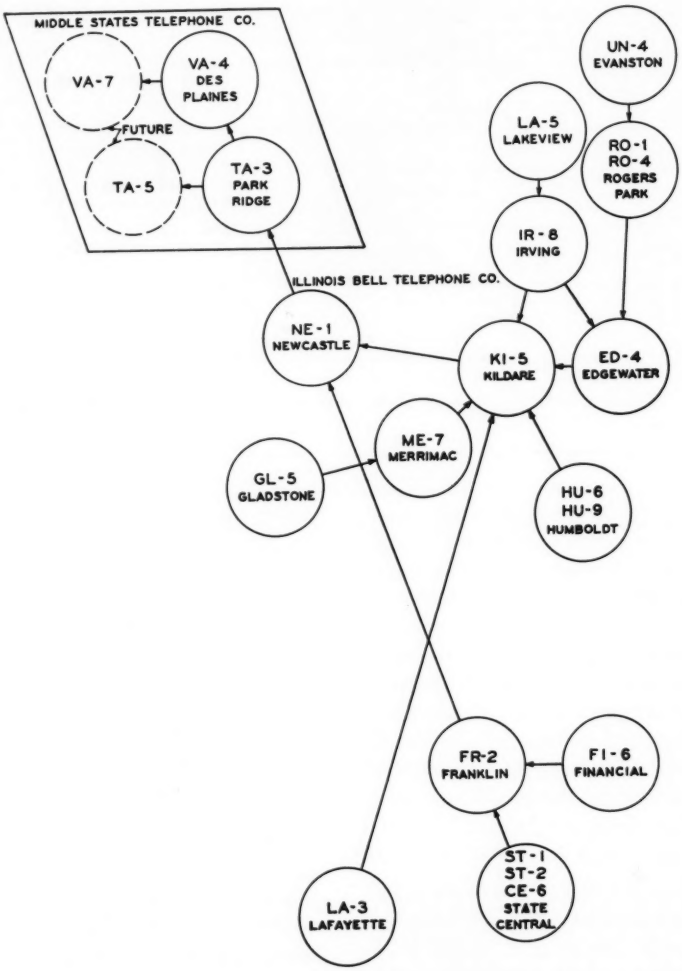


Figure 6. Chicago area Panel and Crossbar offices which have direct subscriber dialing access to the Park Ridge and Des Plaines step-by-step exchanges.

Pulses of the proper speed (10 pps.) required by the Converter for sending to step-by-step switching, originate in a constant-speed, d-c motor-driven pulse generator similar to that used in the universal-type Director.

Special Signals

Inasmuch as revertive pulsing, as previously mentioned, is on an open and closed loop basis for control of revertive sending, it becomes necessary for Converters to operate in a different manner from that expected in normal Strowger step-by-step practice.

In step-by-step systems an open loop normally results in a released connection. The Converter, however, when once seized, must hold the repeater, the selector, and itself in a locked condition until the connection is established, timed-out, or abandoned.

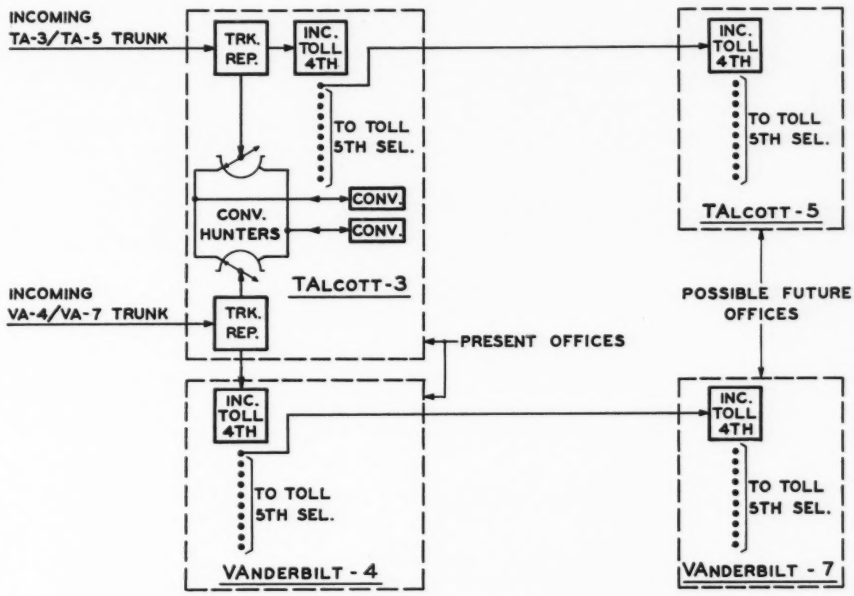


Figure 7. This trunking scheme would make possible two office units in both Park Ridge and Des Plaines, with all the Converters and trunk repeaters located at TAlcott 3.

Release from switched-through calls is effected by the Converter, as explained previously, by causing the trunk repeater to release the Converter.

Timed-out calls are those calls on which receiving and sending is not completed in 20 to 25 seconds. This time interval was chosen so that originating senders would be cleared prior to their own timing-out (which takes place in about 30 to 35 seconds). A timed-out call causes the polarity on the trunk circuit to reverse 120 times per minute, signaling an incomplete call to the originating office. The calling office then releases the originating sender and trunk circuit and sends busy tone back to the calling party.

Similarly, if a call is abandoned after the office code has been dialed, but no other digits are registered on the originating sender, the sender must seize the trunk and Converter selected in order to clear itself. This is accomplished by means of a circuit feature in the Converter which is present during receiving. It consists of certain wiring on the receive switch arranged so that when a connection is made to the particular circuit, the Converter recognizes the fact that more revertive pulses have been transmitted than are usable for the particular selection involved, resulting in an *over-run*. The Converter will then cause the trunk to be reversed in the repeater as a *re-order* and thus clear the connection.

An abandoned call, as mentioned, will allow the Converter to step 11 steps on the incoming brush portion of the receive switch. The maximum possible number of pulses for this selection is 5. Hence, the release of the connection follows.

The same type of over-run release supervision is maintained in the Converter over step-by-step sending; and should the transmitted digit exceed 10 impulses, the connection will be released in the same manner. However, if this happens during sending, the Converter is locked out of traffic and busied, and an audible and visual alarm of the fault is given. This alarm can only be manually released and restored to service at the Converter.

Trunking and Traffic

Equipment economy and geographical placement of the offices at Park Ridge and Des Plaines with respect to the Chicago area determined the type and location of switching units used on calls from revertive pulsing sources.

Trunk repeaters and converters for both Des Plaines and Park Ridge are located at the TAlcott-3 (TA-3) office in Park Ridge. The incoming fourth selector for Des Plaines (VA-4) is reached on a two-wire trunk from its associated repeater at TA-3.

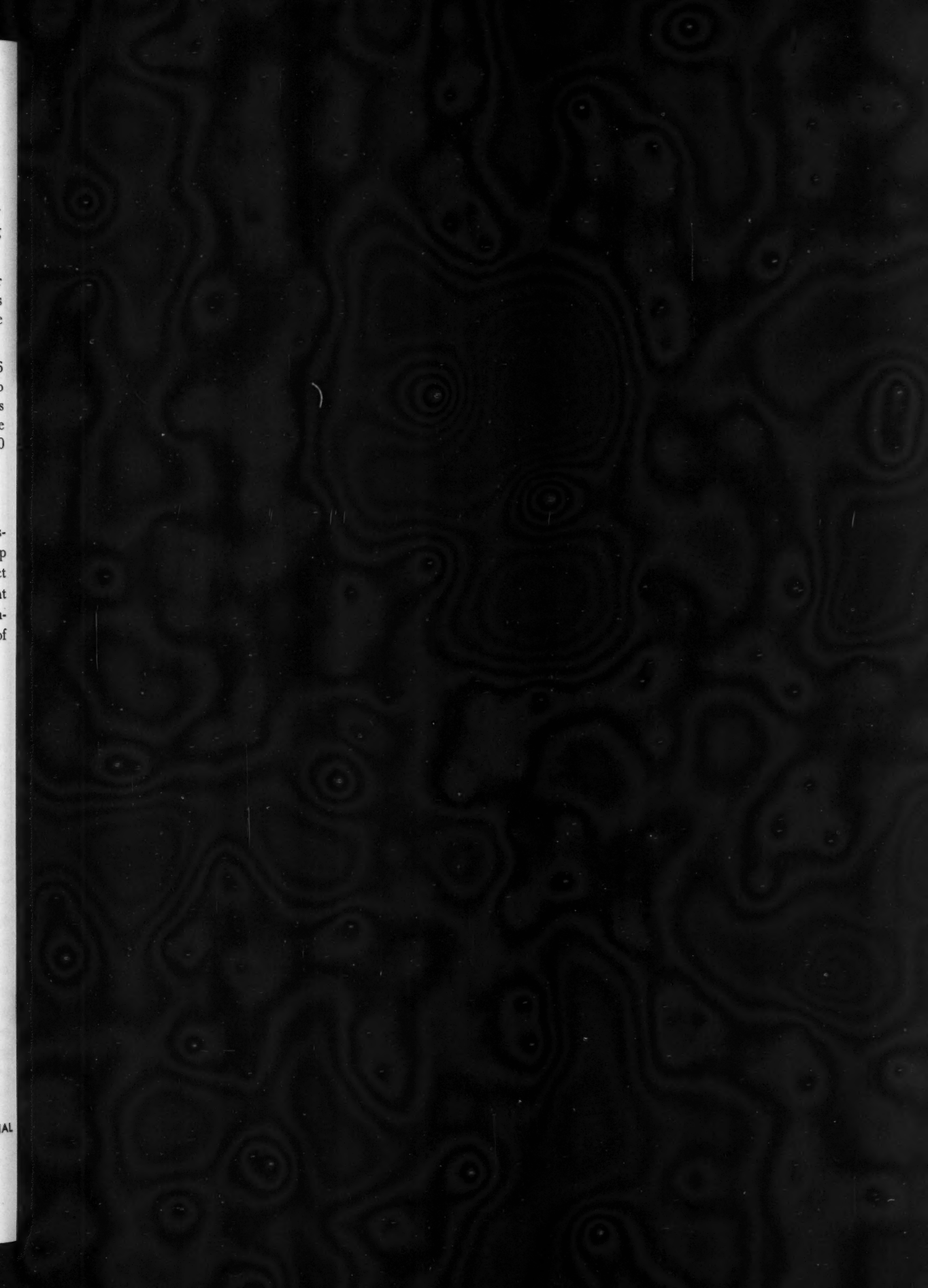
The various metropolitan area offices having access to Park Ridge and Des Plaines are shown in Figure 6. Switching equipment is located only at the originating and terminating ends of a trunk; intermediate offices are merely jumper points.

Future expansion for both TA-3 and VA-4 is insured by the reservation of TA-5 and VA-7 as second office units respectively in the two areas. These new offices could be handled (with all present equipment remaining the same) as *B*, or second unit offices. Of course, the total number of trunks required would have to be increased, but Converter switching functions are at present available to handle second unit calls.

Selection of the *A* or *B* office is controlled by means of the originating sender. A call to the *B* office requires only the addition of five impulses to the incoming group selection to route the call automatically to the second unit. The Converter will send a predetermined, preliminary routing digit prior to the four-digit terminal number.

Figure 7 shows a trunking scheme possible for two office units in each town with all Converters and trunk repeaters located at TA-3, as they are now.

At the present time there are approximately 96 trunks from various Chicago offices leading into the 10 Converters at Park Ridge. Traffic figures supplied by the Middle States company indicate that the 10 Converters are handling about 6,500 calls during a normal 24-hour period.

Conclusions

The Automatic Electric Converter makes it possible for revertive pulses to control step-by-step equipment. Its use will permit establishing direct subscriber dialing between systems using different methods of switch control, thus adding to switching flexibility in areas which include offices of more than one type.